CONNECTICUT RIVER FLOOD CONTROL

LITTLEVILLE

DAM & RESERVOIR

MIDDLE BRANCH, WESTFIELD RIVER, MASSACHUSETTS

DESIGN MEMORANDUM NO. IV

SITE GEOLOGY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS WALTHAM, MASS.

AUGUST 1961

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM 54, MASS.

ADDRESS REPLY TO:
DIVISION ENGINEER

REFER TO FILE NO.

31 August 1961

SUBJECT: Littleville Reservoir, Middle Branch, Westfield River, Connecticut River Basin, Massachusetts, Design Memorandum No. IV - Site Geology

TO: Chief of Engineers
Department of the Army
Washington 25, D. C.
ATTENTION: ENGCW-E

There are submitted herewith, for review and approval, ten (10) copies of Design Memorandum No. IV - Site Geology for Littleville Dam and Reservoir, Connecticut River Basin, in accordance with EM 1110-2-1150.

FOR THE DIVISION ENGINEER:

John Wm Leslie
JOHN WM. LESLIE
Chief, Engineering Division

Incl.
Des. Memo No. IV
(10 copies)

DUAL-PURPOSE FLOOD CONTROL AND WATER SUPPLY PROJECT

LITTLEVILLE DAM AND RESERVOIR

MIDDLE BRANCH, WESTFIELD RIVER

CONNECTICUT RIVER BASIN

MASSACHUSETTS

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* Initial submission in draft to secure approval of spillway design flood and top of dam.

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DESIGN MEMORANDUM NO. IV

SITE GEOLOGY

AUGUST 1961

A. GENERAL TOPOGRAPHY AND GEOLOGY

1. The Littleville Dam site is located on the Middle Branch of the Westfield River approximately 1 mile upstream from the confluence of the Middle and Main Branches of the Westfield River and approximately 2-1/2 miles north of Huntington, Massachusetts. Access to the site is available on a good, hard-surfaced road which runs along the west bank of the river.

2. As shown on General Plan, Plate IV-1, the project consists of an earth fill dam in the main valley approximately 1360 feet long with a maximum height of 164 feet above river level and a dike approximately 935 feet long with a maximum height of 46 feet to close a low saddle on the reservoir rim east of the spillway. The chute type spillway and the adjacent flood control outlet tunnel are located on the left abutment of the dam. A combined low level diversion

conduit and outlet for future water supply to the City of Springfield is located along the left bank of the river channel.

3. The Westfield River flows in a deep, pre-glacial valley in the New England upland section of western Massachusetts. The bedrock hills and ridges are generally blanketed by a thin cover of glacial till consisting of unsorted materials deposited directly from the glacier and ranging in gradation from clay to boulders. The bottom of most of the main valleys have been deeply filled by deposits of till and outwash. The outwash deposits which consist of variable, roughly stratified sand, silt and gravel form narrow flood plains along the valley bottoms and terraces on the valley walls. Bedrock outcrops commonly through the thin till cover on the upper slopes and tops of the hills. In the valleys the bedrock is exposed only where the rivers have cut through the till and outwash to expose rock spurs on the sides of the old, pre-glacial valleys. The bedrock of the region consists of a series of folded Paleozoic crystalline rocks, mostly schist, of several formations. The folds trend generally north-south.

B. DESCRIPTION OF SITE

4. The river flows in a relatively deep, narrow, steep-sided valley at the site. Immediately downstream from the centerline of the dam the river is confined in a narrow channel by boulders and extensive bedrock outcrops. The left abutment is thickly covered with small trees and brush. As shown on Plan of Exploration, Plate IV-2, a small flood plain occurs on the west side of the valley

between the river and the highway. Above the highway a portion of the lower right abutment has been stripped and cleared by a local contractor in operations to obtain sand and gravel. Above the area of borrow operations, the boulder-strewn right abutment is steep and thickly wooded. At the dike site the steep, thickly wooded abutments rise abruptly from the bottom of a flat, marshy saddle.

C. SURFICIAL AND SUBSURFACE INVESTIGATIONS

5. Previous Investigations. An Interim Report on Review of Survey, Littleville Dam and Reservoir was published in April 1956. The results of geological reconnaissance and subsurface explorations consisting of seven borings and three test pits were presented in the report in Appendix B - Geology.

6. Geological investigations were again made at the Littleville site in December 1959 when subsurface explorations were initiated for a combined flood control and water supply dam. These explorations were discontinued for reasons other than geological after completion of four borings, FD-8 through FD-11, and in May 1960 investigations were undertaken at a new site located at Dayville, approximately 3 miles upstream from the Littleville site. At Dayville the investigations consisted of detailed geologic reconnaissances to determine general foundation conditions and to locate sources of borrow materials. Pending firm siting and structure layouts, subsurface explorations were confined to 11 borings made for borrow investigations. In January 1961 investigations for final designs were resumed at the Littleville site.

7. Current Investigations. When work was resumed at the Littleville site, the previous report and all data were reviewed and re-evaluated. Geological reconnaissance of the area was undertaken to locate potential sources of borrow materials, and detailed mapping of outcrops and rock structure was done preparatory to planning design explorations.

8. The foundation exploration for final design as shown on Plan of Exploration, Plate IV-2, consisted of a total of 46 borings and 9 machine excavated test trenches. The borings were made by contract with Sprague and Henwood, Inc., Scranton, Pa. All borings were drive sampled in overburden and, when encountered, the bedrock was "NX" diamond-drill cored using maximum recovery type core barrels, generally to a minimum penetration of 20 feet in bedrock. Hydraulic pressure tests in rock were conducted in 6 borings in the tunnel area, 4 borings along the conduit alignment and 5 borings in the foundation for the weir and embankment. Other explorations consisted of 9 test trenches excavated with a back-hoe to permit visual inspection of the overburden on the left abutment, and some of the trenches were also utilized, in lieu of additional borings at excavation and structure locations, to assist in the determination of the bedrock elevations and the character of the bedrock surface. Detailed classification and descriptions of materials encountered in all foundation explorations are shown in Records of Foundation Exploration, Plates IV-8 through IV-12.

9. Reconnaissance during the early stages of the project indicated that large quantities of relatively pervious and random type materials for embankment construction would be available from some of the extensive terrace and outwash deposits in the area. The general thinness of the till deposits at accessible, nearby locations in the area, however, made location of suitable sources of relatively impervious materials much more problematical. Initial subsurface investigations for borrow materials, therefore, were largely directed toward location of the impervious materials and 7 borings were made for this purpose in a selected area above the right abutment of the dam. In this area, shown on General Plan, Plate IV-1, as Area "A", the borings indicated that although the overburden extended generally to depths of 40 feet or more in most of the area, the material at some of the boring locations appeared to be quite variable with 20 feet or more of generally sandy material overlying the characteristic till. Also, the ultimate extension of the area was restricted by bedrock outcrops along the upstream and uphill sides of the area. Investigations were then directed across the river to Area "B" along Goss Hill Road north of the dike site, as shown on General Plan, Plate IV-1. Borings in this area indicated that a very thick and extensive deposit of generally clayey till occurs along the crest and eastern flank of the ridge and preliminary estimates show that this area could furnish adequate quantities of relatively impervious type materials for construction of the dam and dike. Record of Borrow Exploration, Plate IV-13,

shows the description and detailed classification of materials encountered in borings in impervious Areas "A" and "B".

10. Preliminary explorations consisting of test trenches and auger borings were also done in the outwash and low terrace deposits in the valley bottom extending upstream within the reservoir from the dam to the village of Littleville. These explorations show that in Area "C" immediately upstream from the dam extensive deposits of sandy gravel and gravelly sand occur under a generally continuous blanket of fine sand and silt which ranges in thickness from 1 to approximately 3 feet. Explorations to date in Area "D" and the contiguous Area "E" indicate that relatively pervious materials are also available in these areas. Explorations by borings in the pervious areas are in progress to further determine the characteristics of the available materials and to establish the extent of the deposits for preparation of quantity estimates.

D. SURFICIAL GEOLOGY

11. At the dam site the valley is constricted by encroachments formed mainly on the left abutment by the rapidly rising bedrock surface and on the right abutment by a high terrace. At about the centerline of the dam and extending upstream the valley flairs outward to form a wide, flat flood plain with low, broad terraces occurring continuously along alternate and, occasionally, both sides of the river. Immediately downstream from the centerline of dam the stream has uncovered the bedrock and flows in a series of rapids over

a bedrock and boulder-filled bed. The well-developed terrace which occupies the lower part of the right abutment rises abruptly from the bottom to a height of approximately 70 feet. Above the relatively broad top of the high terrace the right abutment rises steeply in a boulder-strewn slope formed by sandy, till-like materials and poorly developed terraces. Bedrock outcrops on the abutment high above the top of the dam.

12. On the left abutment of the dam the thin to moderately thick overburden consists of till and till-like materials with scattered and poorly developed terraces occurring locally. Bedrock appears as the surface at a few locations on the lower and middle part of the left abutment downstream from centerline of dam but outcrops are not notably lacking upstream from the centerline. Near the top of the left abutment, however, along the crest and upper flanks of the broad ridge which forms the site for the spillway weir, bedrock outcrops persistently in abrupt, long, narrow ribs and extensive areas.

13. The wide, deep saddle at the dike site apparently operated as a spillway for glacial melt water during the recession of the last glacier. Superficial deposits of organic materials occupy the bottom of the saddle. The overburden on the south abutment of the dike is variable and consists generally of till and till-like materials. On the very steep north abutment the overburden is mainly an outwash deposit.

14. The bedrock exposed extensively in and along the river at the site and along the ridge occupied by the spillway is a series of very

steeply dipping schists which trend north-south and dip very uniformly westward at approximately 70°. The very uniform trend and dip of the beds and the differential weathering of the softer and harder schists, as well as their generally thin-bedded character, is well shown by the photographs of typical bedrock exposed in the river channel, Figure 1.

E. FOUNDATION CONDITIONS

15. Overburden.

a. The overburden on the left abutment of the dam consists of a till cover of varying thickness on which rests scattered, irregular and variable outwash and terrace deposits of silty sand, gravelly sand and sandy gravel. Cobbles and boulders occur scattered throughout and in local concentrations, and covering much of the area is a wide-spread thin blanket of fine sandy silt. The till which generally rests on bedrock ranges from a characteristically compact gravelly, silty sand or silty sandy gravel to loose, modified till or till-like materials consisting of silty gravelly sand, silty sand or sandy silt. Underlying the till in scattered local areas but particularly in troughs in the bed-rock surface are lenses and pockets of sand and gravel, and throughout much of the abutment the till rests on or is mixed with soft, micaceous, decomposed and weathered rock. The overburden on the left abutment along and downstream from the centerline of dam is generally less than 10 feet thick. On the upstream side of the centerline, however, the overburden ranges in thickness from 10 to more than 25 feet.

b. In the valley bottom and on the lower right abutment of the dam, thick deposits of outwash occur overlying till or bedrock.

TYPICAL BEDROCK EXPOSED IN RIVER CHANNEL

LITTLEVILLE DAM SITE

FIGURE 1

In the valley section of the foundation the outwash consists of variable sands and gravels to depths of 50 feet or more. As shown on Geological Sections, Plates IV-3 and IV-4, these materials appear to rest directly on the bedrock along the left side of the buried valley, and upstream from centerline of dam this condition exists in a widening area toward the right abutment. These materials do not appear to be typically well-sorted sands and gravels throughout. Particularly below depths of 25 to 35 feet in some areas, occasional samples from the borings appear to be modified till or till-like in character. On the right abutment the overburden consists of till varying from 40 to more than 70 feet in thickness, which rests on the bedrock and is covered by outwash and terrace materials of variable thickness and character. In the well-developed terrace along the lower part of the right abutment the till is buried to depths of 35 or more feet but on the abutment above the terrace, till is generally encountered at depths of less than 20 feet. The till is characteristically variable but consists mainly of gravelly, silty sand and silty, gravelly sand with cobbles and boulders. As exposed by operations in the existing borrow pit, the materials in the terrace include completely unstratified and unsorted, modified till and till-like zones and poorly to well-stratified pockets and lenses of well-sorted sands and gravels. Very numerous cobbles and boulders occur in local concentrations and scattered throughout the terrace materials. Above the big terrace the outwash and minor terraces which occur on the abutment overlying the till are composed mainly of silty, gravelly sand and silty, sandy gravel with numerous cobbles and large boulders.

c. At the dike site the overburden on the south abutment is mainly till composed of gravelly, silty sand and silty, gravelly sand with cobbles and boulders. Bedrock occurs under the till at depths of 10 to 20 on the south abutment. The bedrock surface slopes very steeply northward, however, so that it is deeply buried under the bottom of the wide saddle and under the north abutment. In these areas of the dike foundation, the overburden apparently consists of two till or till-like zones separated by, and in the north abutment overlain by, outwash materials The lower till is mainly a compact, gravelly silty sand which apparently continues downward with the bedrock surface toward the north so that it is not encountered at explored depths of 50 feet under the north abutment. Overlying the lower till are stratified outwash deposits more than 20 feet thick consisting of materials ranging from silty sand and gravelly sand to sandy gravel. The upper till which covers the stratified outwash occurs in a zone approximately 25 feet thick and includes variable, sandy till and till-like materials. Although the borings indicate the persistence of this zone through the dike foundation, the nature of the deposits and the variability of the materials in this area make the actual thickness and continuity of the upper till zone questionable. In the north abutment of the dike the upper till is overlain to depths of more than 40 feet by outwash deposits consisting of silty fine sand and silty, gravelly sand. In the bottom of the saddle, superficial deposits of organic materials have accumulated to depths up to 3 feet.

d. Along the alignment of the diversion and low level conduit, the overburden is generally less than 8 to 10 feet thick except in local troughs in the rock surface and upstream from the centerline of dam where poorly-developed, small terraces form local mounds up to 20 feet in thickness. The overburden consists mainly of silty sands and silty sandy gravels with numerous cobbles and boulders. At the intake area of the conduit the bedrock is overlain directly by approximately 10 feet of material consisting of silty sand apparently mixed with and partly underlain by soft, very badly weathered boulders and rock blocks.

e. At the spillway and discharge channel area the overburden is generally less than 12 feet thick. Along the upper part of the discharge channel area the overburden consists of till, mainly gravelly, silty sand, and weathered rock. Where the flood control outlet enters the discharge channel and extending downhill to the river, the till and till-like materials are overlain by poorly developed knobby terraces and outwash consisting of variable silty sands and gravels. Similarly, in the flood control outlet approach and discharge channels, the overburden consists of thin deposits of silty sands and gravels underlain by till and weathered rock.

16. Bedrock.

a. Bedrock throughout the entire site as observed at the extensive areas of exposed bedrock in the stream channel and on the left abutment, and as shown by the rock cores, consists of a series of thin-bedded, steeply dipping mica schists with occasional thin beds of quartz schist or quartzite and hornblende schist. The main member of the mica schist series and by far the predominant rock type at the site is quartz-sericite schist which, as shown by petrographic examination of thin sections, is commonly graphitic, very well foliated, soft to moderately hard and coarse-grained. Interbedded with the sericite schist are numerous thin beds of quartz-biotite schist which are generally harder, finer-grained and more durable. The quartz schist or quartzite beds are very hard so that wherever observed, the individual beds which are generally less than 3 or 4 feet thick, form prominent ribs on the rock surface. The hornblende schist also occurs in thin beds, is usually calcareous and even includes some zones of the original, unaltered limestone from which it was derived. Locally, pegmatite dikes and small quartz and diabase dikes cut all the rocks, and in these areas the adjacent schists tend to appear granitic and grade into gneiss. The trend of the bedrock is very consistently North-South, and the dip of the beds is uniformly westward at approximately 60° to 70°. The bedrock has very irregular surface which is characteristic of these thin-bedded schists with long, narrow ribs and ridges occurring between deep troughs and pockets. Below the nominally sound bedrock surface, the rock is weathered along closely-spaced open foliation planes and joints to depths generally in the order of 2 to 5 feet, except locally where the weathered and closely-broken rock may extend to depths up to 10 feet. Below this upper weathered zone, the rock as a whole is generally fresh with weathering confined to thin zones along numerous to occasional foliation planes and joints and to local zones of close jointing or fracturing which, in many of the borings, occurs to the full depth of the holes. Small solution cavities occur in calcareous zones associated with the limy hornblende schists at many of the locations where these rocks are encountered.

b. Evidence of faulting at the site was found in boring FD-17 located on the right abutment of the dam, where the rock core throughout the entire depth of 35 feet below the rock surface showed very badly weathered, fractured and brecciated rock. Additional indications of small slips and movement were shown by slickensides and small breccia-filled seams encountered in borings FD-25 and FD-26, in the vicinity of the flood control outlet tunnel, and at boring FD-30 located on the right abutment of the dam. Hydraulic pressure tests in rock, which were conducted in some of the borings at structure locations, generally show very small water losses with less than 5 gpm loss at pressures up to 30 psi being recorded during most of the tests. It should be noted, however, that in some of these tests the packers could not be sealed to the sides of the hole on account of open seams or broken zones. The results of all pressure tests are shown graphically in the Record of Foundation Exploration, Plates IV-8 through IV-12, and on the Geologic-Log Sections, Plates IV-5 through IV-7.

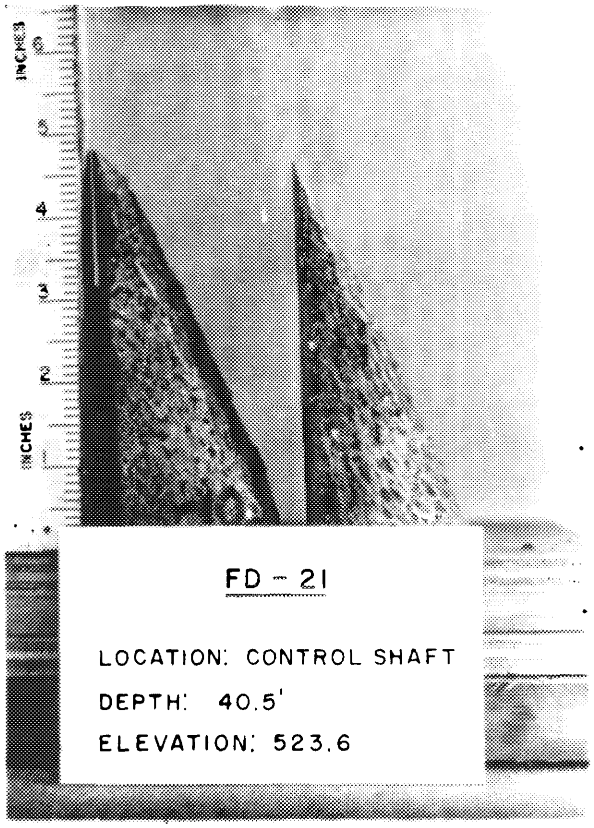
c. Average bulk density of the typical rock to be tunneled is 175 pounds per cubic foot. Unconfined compression tests made on 2-1/8-inch diameter cores of typical quartz-sericite schist from the tunnel area showed a range of strengths from 591 psi to 1098 psi. The low compressive strengths are not untypical for finely foliated rock when tested out of normal restraint. Photographs of the rock samples after the tests showing the agreement between the failure surfaces and the natural foliation in the rock are presented in Figure 2.

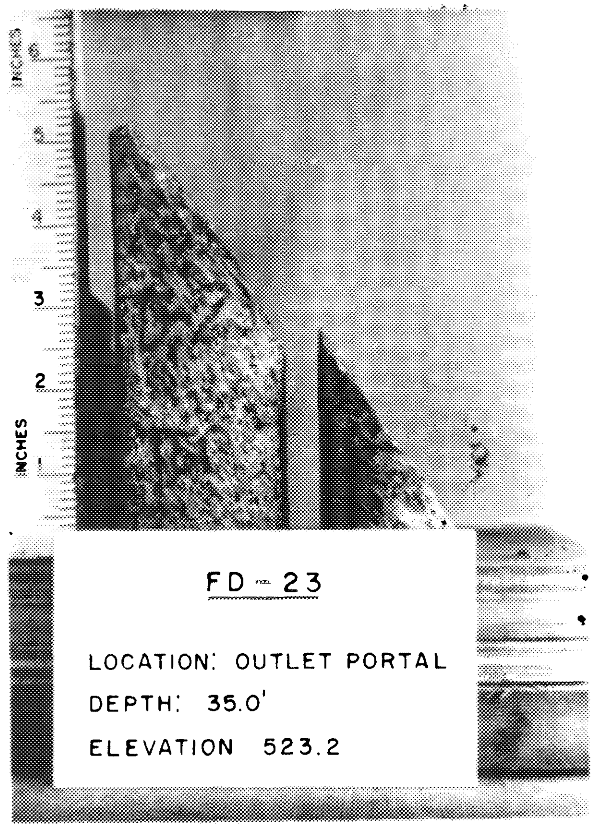
F. SUBSURFACE WATER

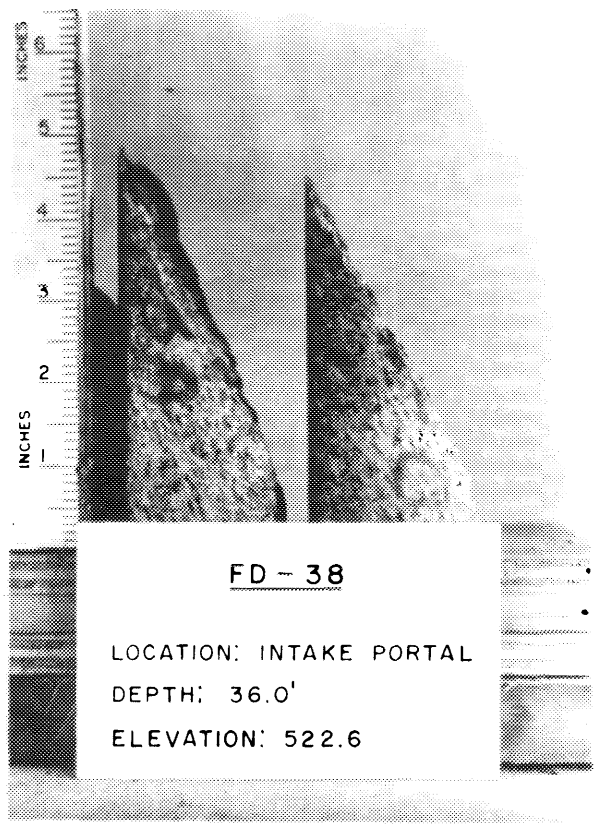
17. Levels of subsurface water are indicated by observations in borings during drilling operations and by observation wells installed in some of the borings. In the valley bottom the level is essentially at river elevation and on the right abutment appears to coincide with the upper surface of the till. On the left abutment and the ridge at the spillway site, ground water generally occurs at or below the rock surface. Excavations on the abutment or ridge, however, may encounter water trapped in troughs in the rock surface or seasonal runoff from fissures in the rock. On the south abutment at the dike site, subsurface water levels appear to be at the upper surface of the till. In the bottom of the saddle and on the north abutment the subsurface water levels apparently occur generally at depths of 20 to 30 feet.

G. RESERVOIR LEAKAGE AND RESOURCES

18. The sides of the valley inclosing the water supply reservoir are wide bedrock and till ridges which are higher than the water supply pool at Elevation 518 m. s. l. The relatively pervious materials extending to bedrock in the left of the valley bottom at the dam site will be cut off to the rock surface by impervious backfill and elsewhere the







TEST SPECIMENS OF ROCK FROM TUNNEL ROOF AREA
SHOWING COMPRESSION FRACTURES

LITTLEVILLE DAM SITE

FIGURE 2

dam embankment will be provided with an impervious cut-off to glacial till or bedrock. In addition, a grout curtain will be constructed where cut-off is made to the rock surface. At the site of the dike, which is entirely above the elevation of the permanent pool and is required for closure of a saddle in the flood control reservoir, a deep valley filled with variable pervious materials and till occurs under and adjacent to the north abutment. The dike embankment will be provided with an upstream impervious blanket or an impervious cut-off to bedrock or glacial till in the north or left abutment.

19. The reservoir is located in a pegmatite district which is a potential source of beryl, feldspar and mica but there are no known operating sources or prospects in the area. Sand and gravel have been sporadically excavated from the terraces in the valley for local processing for aggregates.

H. CONSTRUCTION MATERIALS

20. General. Embankments for the dam and the dike will be essentially of the homogeneous impervious type with internal drainage features and rock slope protection with gravel bedding. A small random zone in the dam embankment will be provided to utilize material from required earth excavation.

21. Impervious and Random Materials.

a. In Area A located above the right abutment of the dam as shown on General Plan, Plate IV-1, the overburden consists mainly of till overlain to depths of 5 to 15 feet in a large part of the area by variable, modified tills and terrace materials. The main till deposit consists, for the most part, of gravelly, silty sand with cobbles and boulders. The till is characteristically variable, however, and contains extensive phases which range from silty, gravelly sand to silty, fine sand. The overlying variable deposits consist of both unstratified and partly stratified materials in a wide range of gradations from silty gravelly sand to silty sandy gravel. In view of the heterogeneous character of the materials in Area A and the relatively limited quantities potentially available there, decision has been made tentatively either to consider this area as a potential reserve for random-type fill only or to abandon consideration of its use for any purpose.

b. In Area B, located as shown on General Plan, Plate IV-1, on the high ridge north of the dike site, the crest and eastern flank of the ridge are underlain generally by very thick deposits of till. The till is composed mainly of compact, relatively impervious gravelly, silty-clayey sand and gravelly, sandy silt with scattered cobbles and boulders. Estimates indicate that adequate quantities of the till are available in the area for all requirements for this type material in construction of dam and dike embankments.

22. Pervious Materials. Extending upstream in the reservoir from the dam site the extensive outwash and terrace deposits in the valley were explored by machine excavated test trenches and auger borings. In Area C, located on the east side of the river immediately upstream from the dam site, as shown on General Plan, Plate IV-1,

relatively pervious materials consisting of stratified gravelly sands and coarse gravels occur under a 1- to 3-foot blanket of sandy silt. The stratified materials, as exposed in explorations to date, extend to depths of at least 10 feet throughout most of the area. Preliminary estimates indicate that a very large part of the pervious fill materials required for the embankments could be obtained from this area. In Area D, located immediately upstream on the west side of the river, preliminary exploration indicates that the materials are generally finer than in Area C and consist, for the most part, of fine to coarse sands and gravelly sand. These materials are, however, relatively pervious and could be used in appropriate sections of the embankments. In Area E coarser materials were encountered in initial explorations and continuing investigations are being made to better develop the character and extent of this potential source of coarse, pervious fill material.

23. Rock Fill. A large quantity of rock for fill and slope protection will be available from excavations in bedrock at the site. The bedrock in most of the excavation areas consists mainly of quartz-sericite schist with numerous thinner beds of quartz-biotite schist, quartzite and hornblende schist. Although these rocks in place are relatively hard and fresh below the nominally thick weathered zone, they are thinly foliated, closely jointed in some areas, and consist largely of mica, both disseminated generally and in local concentrations. The tendency will be, therefore, for blasting, excavation and

handling to produce slabby, elongated shapes and a high proportion of fine sizes. It must be expected that little or none of the rock from tunnel excavations will be suitable for use in rock fills. Boulders from required excavations and stripping can be used, however, and if required, additional rock can be obtained by quarrying.

24. Concrete Aggregates. The quantity of concrete required for construction of the planned tunnel, outlet works and spillway structures is approximately 15,000 cubic yards. In view of the relatively small quantity of concrete required, investigations of sources of aggregate material were limited to consideration of commercial producers within 25-mile haul distance of the site. Tests on aggregates from three commercial plants within a 20-mile haul distance are presented in Design Memorandum III, Concrete Materials.

I. CONCLUSIONS AND RECOMMENDATIONS

25. The topography and geology of the reservoir guarantee impoundment for the low level permanent pool for future water supply and for high level temporary flood control pools. Geologic site conditions are generally suitable for the proposed structures, and design and specifications are being prepared with full consideration to geologic factors bearing on excavations, foundations, leakage and natural borrow materials.

26. Special problems of an engineering geology nature are not anticipated during construction. However, in accordance with recently established practice of this Division, a digest of geologic factors involved

in the design and considered in the construction of the project will be furnished to field construction personnel as background, guidance and instruction for the work. This digest will point out the availability for field consultation of geology personnel, particularly at the outset and during major or critical rock excavations and grouting operations.

27. The alignment of the water supply conduit is nearly parallel to the trend of the rock structure and the alignments of the flood control tunnel and spillway channel cross the rock structure at very small angles. This relationship of excavations to rock structure will result in control of breakage to a large degree by the dip of foliation and bedding aided by the natural tendency for slipping of graphitic and sericitic phases of the schist. This condition has been considered in the design of open cut excavations with slopes on the eastern or up-dip sides tentatively made 3 vertical on 1 horizontal to approximate the dip of foliation. The overburden will be cleaned off to leave a 10-foot berm along the top of all rock cuts as a general safety measure and in the deeper cuts on up-dip slopes will serve for inspection of incipient or open cleavages that may result in slips or slides. Where the deeper rock cuts may encounter an upper, weathered zone, it may be necessary to flatten the upper slopes or make 10-foot berms at the level of relatively sound rock. Rock bolts will be provided for and may be applicable on the up-dip slopes of open cut excavations. Proper scaling and the application of safety mesh with rock bolt fastening will be stressed in deep and in confined excavations.

28. The schist bedrock, despite its inherent structural weakness out of natural restraint, will serve adequately in place below weathered zones for heavy structural loads. During progress of explorations, it was apparent from a reasonable number of borings that rock was rather critically available for foundation of the water supply intake tower and conduit and for cover at the flood control tunnel intake portal. However, there was concern as to the ridge and trough condition of the rock resulting in pockets which could only be discovered by an inordinate amount of exploration. It was recommended and found possible to insure rock foundation and cover by moving the water supply conduit about 18 feet into the left lower abutment and lowering the invert of the tunnel by 5 feet. As reported under Foundation Conditions herein, there are scattered indications from subsurface explorations of old faulting but there is no correlative evidence that major crushed zones will be encountered in excavations.

29. The schist is not adaptable to line drilling or pre-splitting methods except to a rough degree on the down-dip or western slopes of excavations. However, line drilling will be included in the specifications for use in critical areas such as at the junction of excavations for flood control outlet and spillway channels. Provision will be made for discontinuance of line drilling if the results attained are no more preserving of rock beyond line holes than a normal close pattern of drilling.

30. The flood control tunnel will be 10 feet in excavated diameter, approximately 375 feet in length, with a central shaft and transition of 20 feet in excavated width. The rock condition is considered most comparable to Terzaghi's Condition No. 4, and the recommended loading for design of structural steel and reinforced concrete support is 0.35 $(B+H_t)$. Overbreak will be greatly influenced by the dip of schist foliation with control particularly difficult to exercise in the crown where a peaked or cathedral type roof may occur. Rock bolt type of roof support will be used as a supplement and as a substitute to conventional steel support where applicable. Contact grouting will be performed to fill overbreak voids between the crown lining and roof rock.

31. Grout curtains will be constructed under impervious sections of the dam, in embankment cutoffs and at major concrete structures to assist in the control of seepage and reduction of uplift. Hydraulic-pressure tests performed in exploratory borings generally indicate that take of grout will be nominal. Drain holes will be drilled in rock as necessary for structures, walls and slabs. Anchors will be inclined in relation to rock structure to engage the maximum quantity of rock.

32. Although normal rock excavations should produce a large quantity of suitable sizes and shapes for use in rock fills and slope protection, it should be expected that the inherent structural weakness of the rock in some areas will tend to produce slabby fragments and that concentrated mica zones will produce undesirable fines.

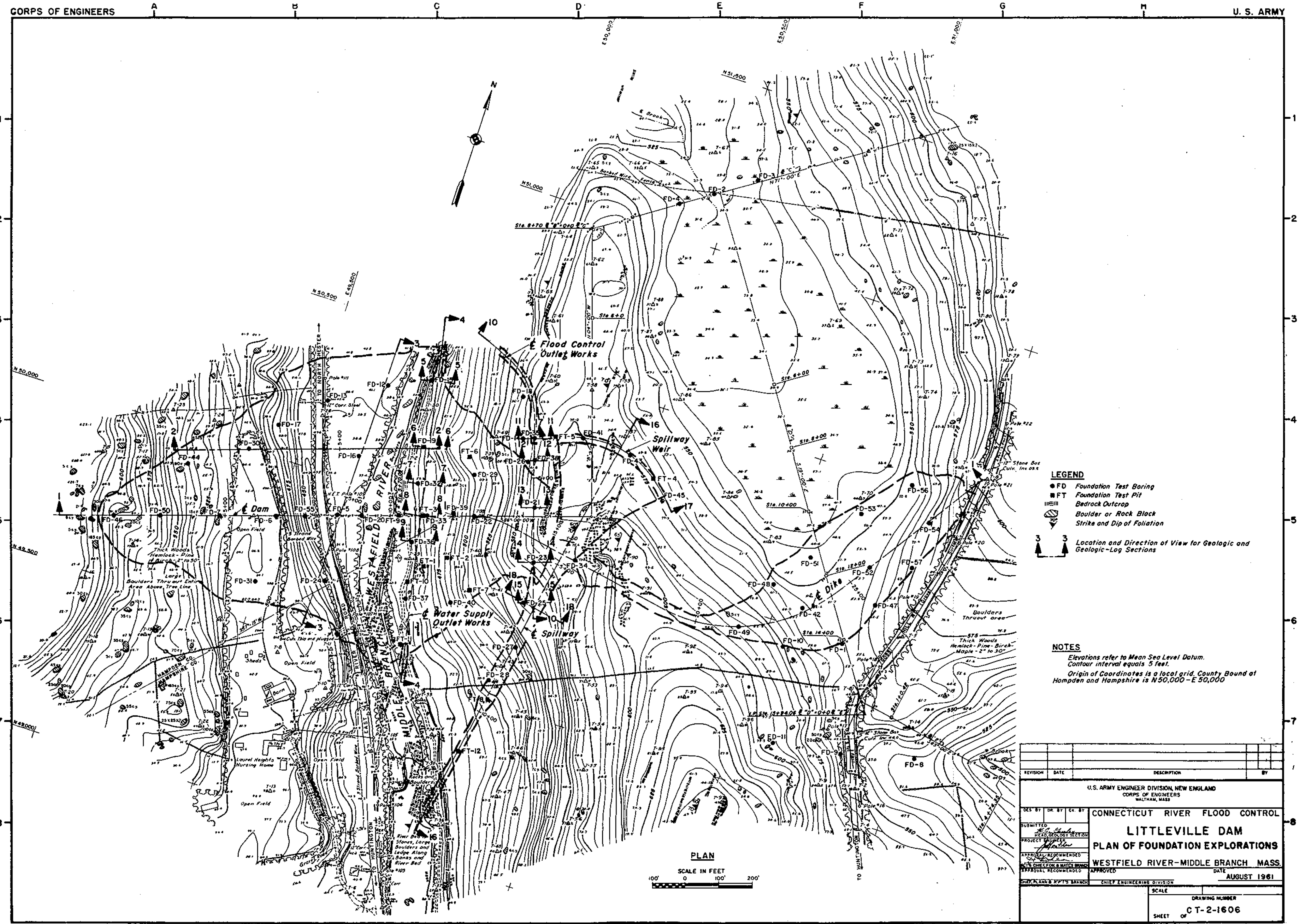

CORPS OF ENGINEERS
U. S. ARMY
Flood Control Outlet Works
Spillway Weir
Water Supply Outlet Works
Spillway
Dam
Dike
WESTFIELD RIVER
MIDDLE BRANCH
PLAN
SCALE IN FEET
LEGEND
● FD Foundation Test Boring
■ FT Foundation Test Pit
Bedrock Outcrop
Boulder or Rock Block
Strike and Dip of Foliation
Location and Direction of View for Geologic and Geologic-Log Sections
NOTES
Elevations refer to Mean Sea Level Datum.
Contour interval equals 5 feet.
Origin of Coordinates is a local grid. County Bound at Hampden and Hampshire is N50,000 - E50,000
REVISION
DATE
DESCRIPTION
BY
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS
DES. BY
DR. BY
CK. BY
SUBMITTED
HEAD, GEOLOGY SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED
APPROVAL RECOMMENDED
CHIEF, PLANN & RPTS BRANCH
CONNECTICUT RIVER FLOOD CONTROL
LITTLEVILLE DAM
PLAN OF FOUNDATION EXPLORATIONS
WESTFIELD RIVER-MIDDLE BRANCH MASS.
APPROVED
CHIEF ENGINEERING DIVISION
DATE
AUGUST 1961
SCALE
DRAWING NUMBER
SHEET OF
CT-2-1606

PLATE NO. IV - 2

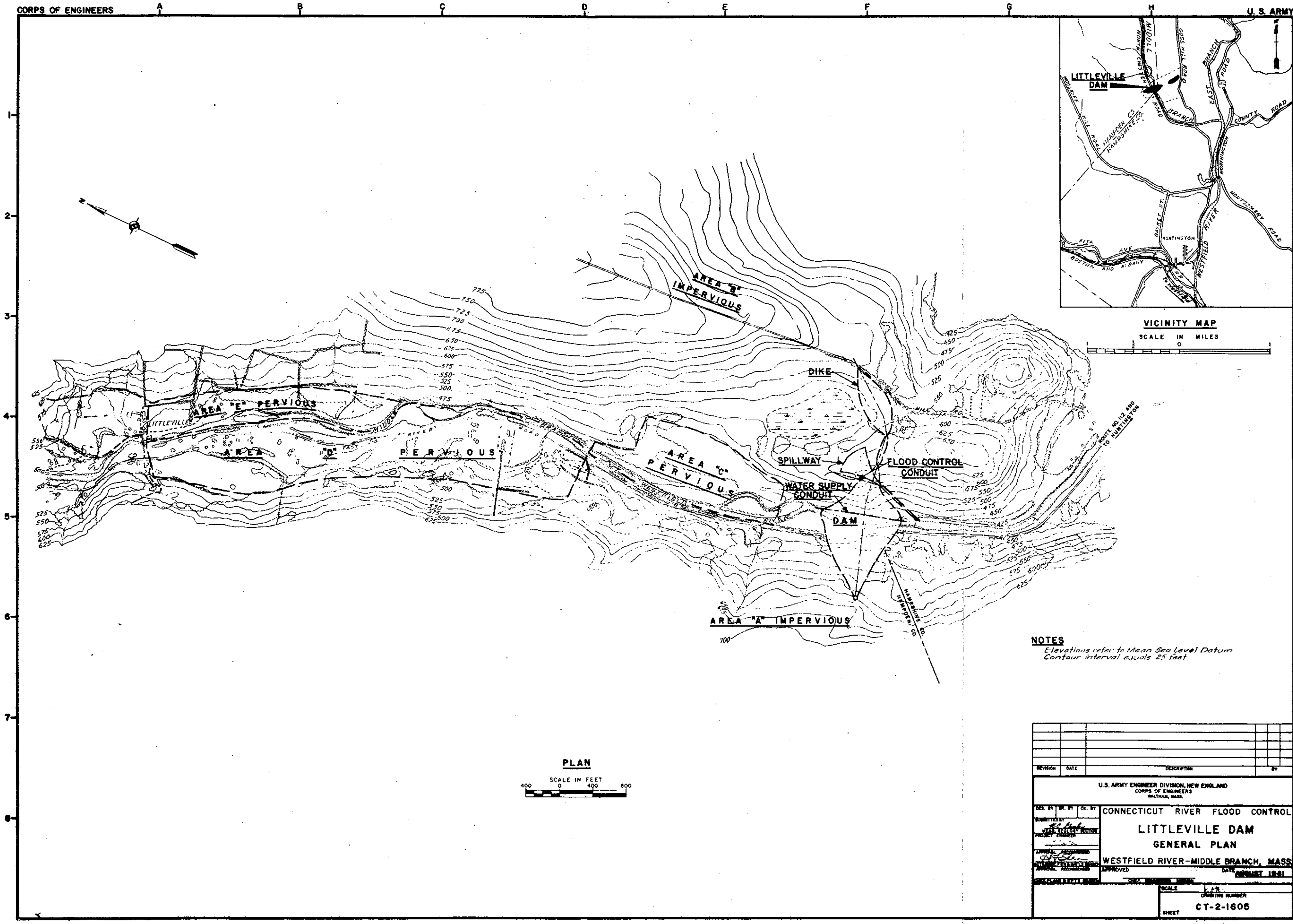
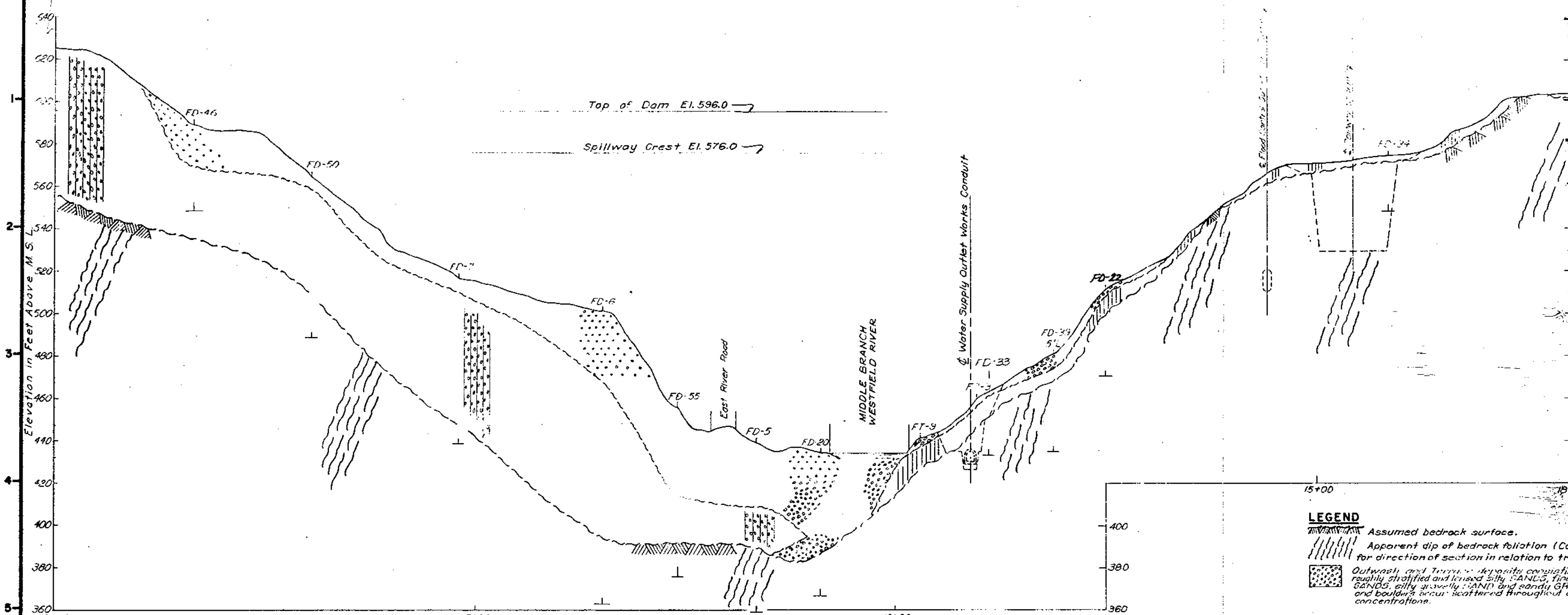
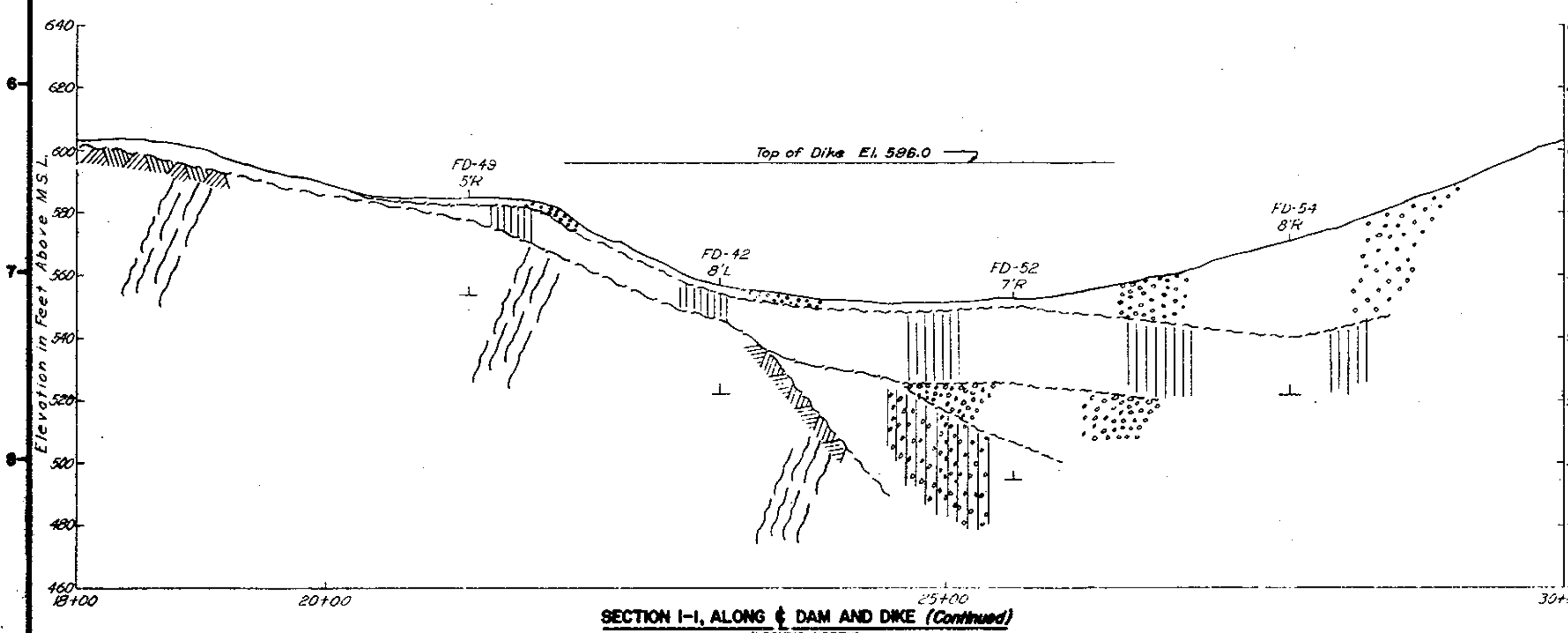

CORPS OF ENGINEERS
U. S. ARMY
LITTLEVILLE DAM
VICINITY MAP
SCALE IN MILES
HUNTINGTON
WESTFIELD RIVER
AREA "B" IMPERVIOUS
AREA "E" PERVIOUS
LITTLEVILLE
AREA "D" PERVIOUS
AREA "C" PERVIOUS
DIKE
SPILLWAY
FLOOD CONTROL CONDUIT
WATER SUPPLY CONDUIT
DAM
AREA "A" IMPERVIOUS
ROUTE NO. 112 AND TO HUNTINGTON
NOTES
Elevations refer to Mean Sea Level Datum
Contour interval equals 25 feet
PLAN
SCALE IN FEET
400 0 400 800
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
CONNECTICUT RIVER FLOOD CONTROL
LITTLEVILLE DAM
GENERAL PLAN
WESTFIELD RIVER-MIDDLE BRANCH, MASS.
AUGUST 1961
CT-2-1605

PLATE NO. IV - 1

CORPS OF ENGINEERS | U. S. ARMY



SECTION I-I, ALONG ℄ DAM AND DIKE
(LOOKING NORTH)



SECTION I-I, ALONG ℄ DAM AND DIKE (Continued)
(LOOKING NORTH)

LEGEND

Assumed bedrock surface.

Apparent dip of bedrock foliation (Corrected for direction of section in relation to true dip)

Outwash and Terrace deposits consisting of variable, roughly stratified and lensed silty SANDS, fine to coarse SANDS, silty gravelly SAND and sandy GRAVEL. Cobble and boulders occur scattered throughout and in local concentrations.

Sandy TILL and TILL-LIKE materials ranging from gravelly SANDS and silty, sandy GRAVEL to gravelly silty SAND. Cobbles and boulders occur scattered throughout and in local concentrations. Also includes some zones of weathered bedrock.

TILL-Variable gravelly, silty SAND, with numerous cobbles and boulders

Bedrock consists mainly of graphitic, and locally calcareous quartz sericite SCHIST with many thin beds of quartzitic, biotite and hornblend SCHIST.

NOTES

For Location of Sections, see Plate No. 2

For Record of Foundation Explorations, see Plate Nos. 8, 9, 10, 11 and 12.

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY H.A.V. | DR. BY H.T.P. | CK. BY H.A.V.

CONNECTICUT RIVER FLOOD CONTROL

LITTLEVILLE DAM

DAM AND DIKE

GEOLOGIC SECTION

WESTFIELD RIVER-MIDDLE BRANCH, MASS.

DATE AUGUST 1961

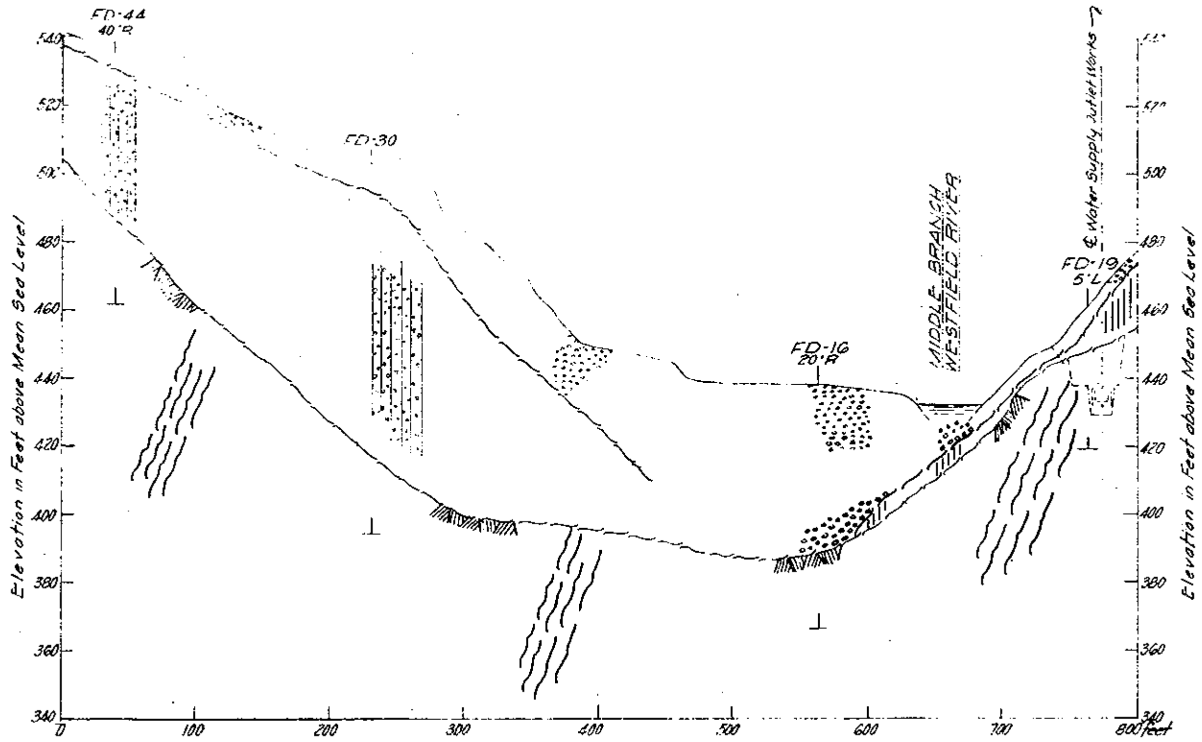
SCALE

CT-2-1607

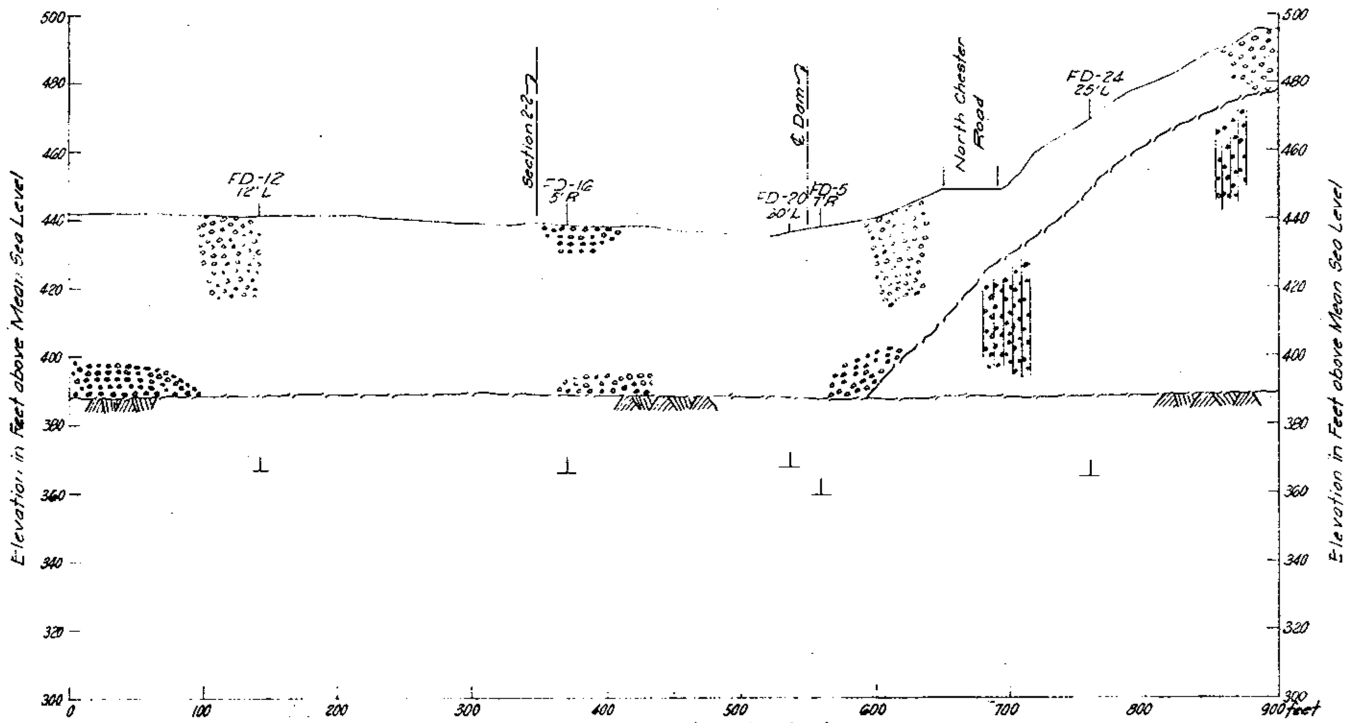
SHEET

PLATE NO. IV - 3

CORPS OF ENGINEERS U. S. ARMY



SECTION 2-2
(LOOKING NORTH)



SECTION 3-3 *(Longitudinal)*
(LOOKING EAST)

NOTES

For Location of Sections, see Plate No. 2
For Record of Foundation Explorations, see Plate Nos. 8, 9, 10, 11 and 12
For Legend of Geologic Symbols, see Plate No. 3

REVISION	DATE	DESCRIPTION	BY

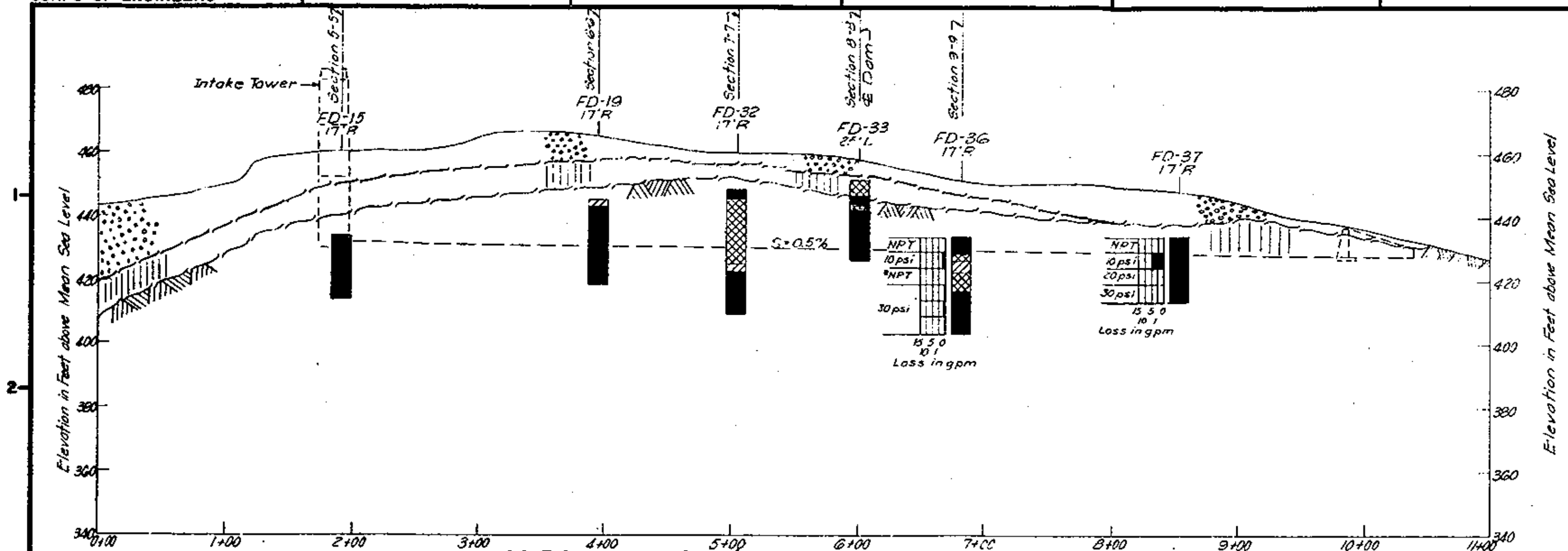
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

CONNECTICUT RIVER FLOOD CONTROL
LITTLEVILLE DAM
DAM
GEOLOGIC SECTIONS
WESTFIELD RIVER-MIDDLE BRANCH, MASS.

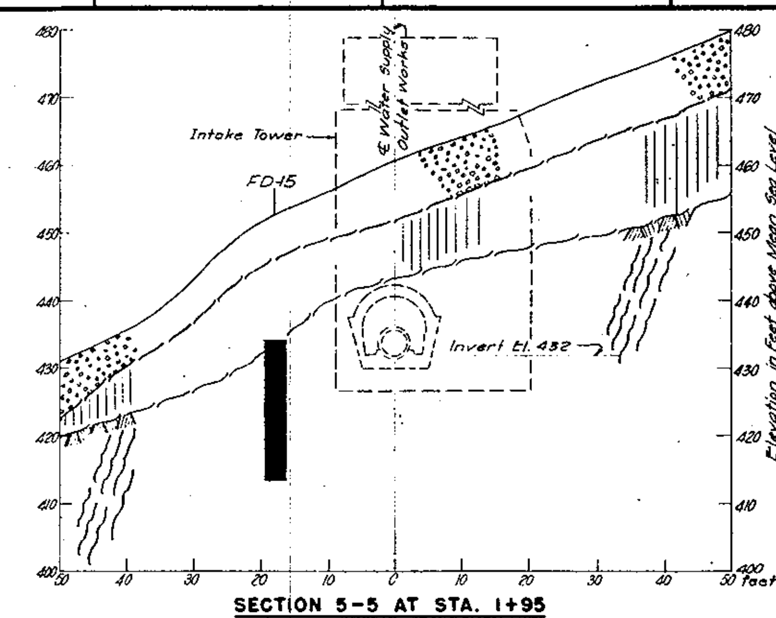
APPROVED
DATE AUGUST 1961
SCALE
DRAWING NUMBER
CT-2-1608
SHEET

PLATE NO. IV - 4

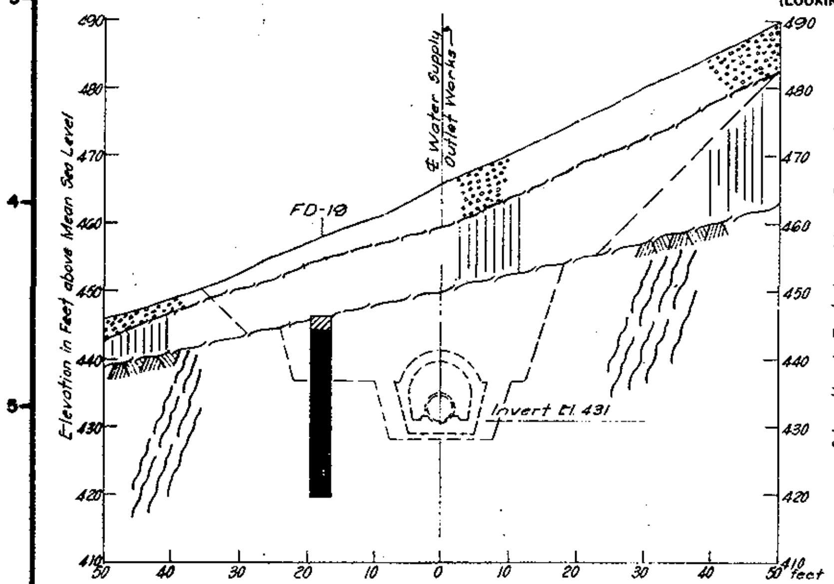
CORPS OF ENGINEERS U. S. ARMY



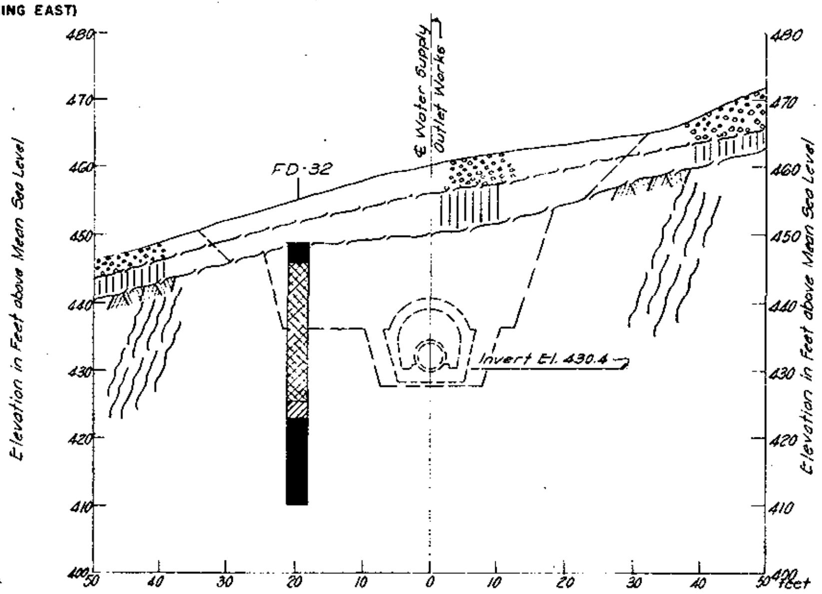
SECTION 4-4 ALONG € WATER SUPPLY OUTLET WORKS
(LOOKING EAST)



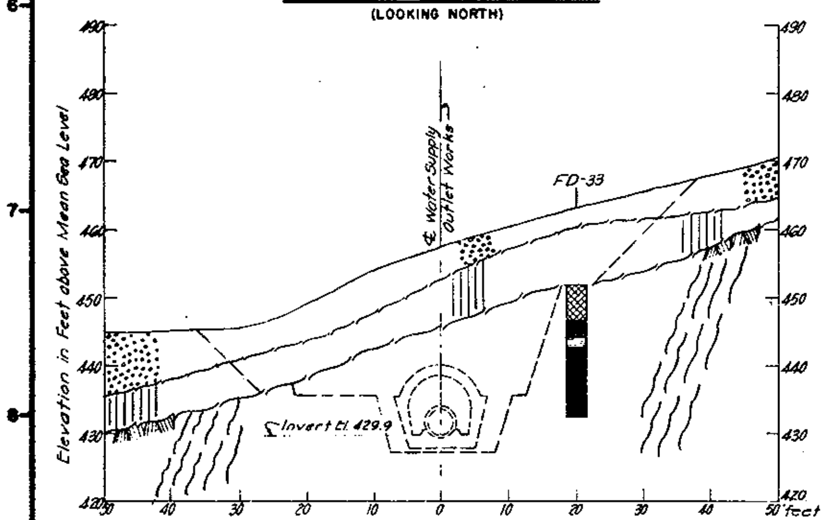
SECTION 5-5 AT STA. 1+95
(LOOKING NORTH)



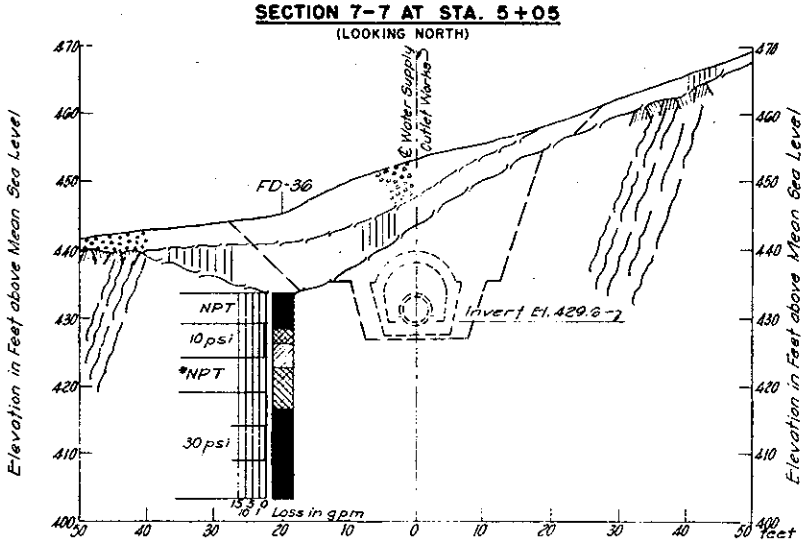
SECTION 6-6 AT STA. 3+95
(LOOKING NORTH)



SECTION 7-7 AT STA. 5+05
(LOOKING NORTH)



SECTION 8-8 AT STA. 6+00
(LOOKING NORTH)



SECTION 9-9 AT STA. 6+90
(LOOKING NORTH)

LEGEND FOR CORE BORING IN ROCK

FD-37 Foundation Test Boring
17'R Distance and direction of offset

NPT
10 psi
20 psi
30 psi
15 5 0
10 1
Loss in gpm

0-25% Rock core recovery
25-50% Rock core recovery
50-75% Rock core recovery
75-90% Rock core recovery
90-100% Rock core recovery

*NPT No pressure test performed. Asterisk denotes that section could not be sealed for testing

15 psi Constantly maintained pressure for 1 to 5 minutes. Volume loss in gallons per minute under constant pressure, tested continuously in 5-foot sections. Scale expanded from 0 gpm to 1 gpm for clarification of low pressure losses.

NOTES

For Location of Sections, see Plate No. 8

For Record of Foundation Explorations, see Plate Nos. 8, 9, 10, 11 and 12.

For Legend of Geologic Symbols, see Plate No. 3

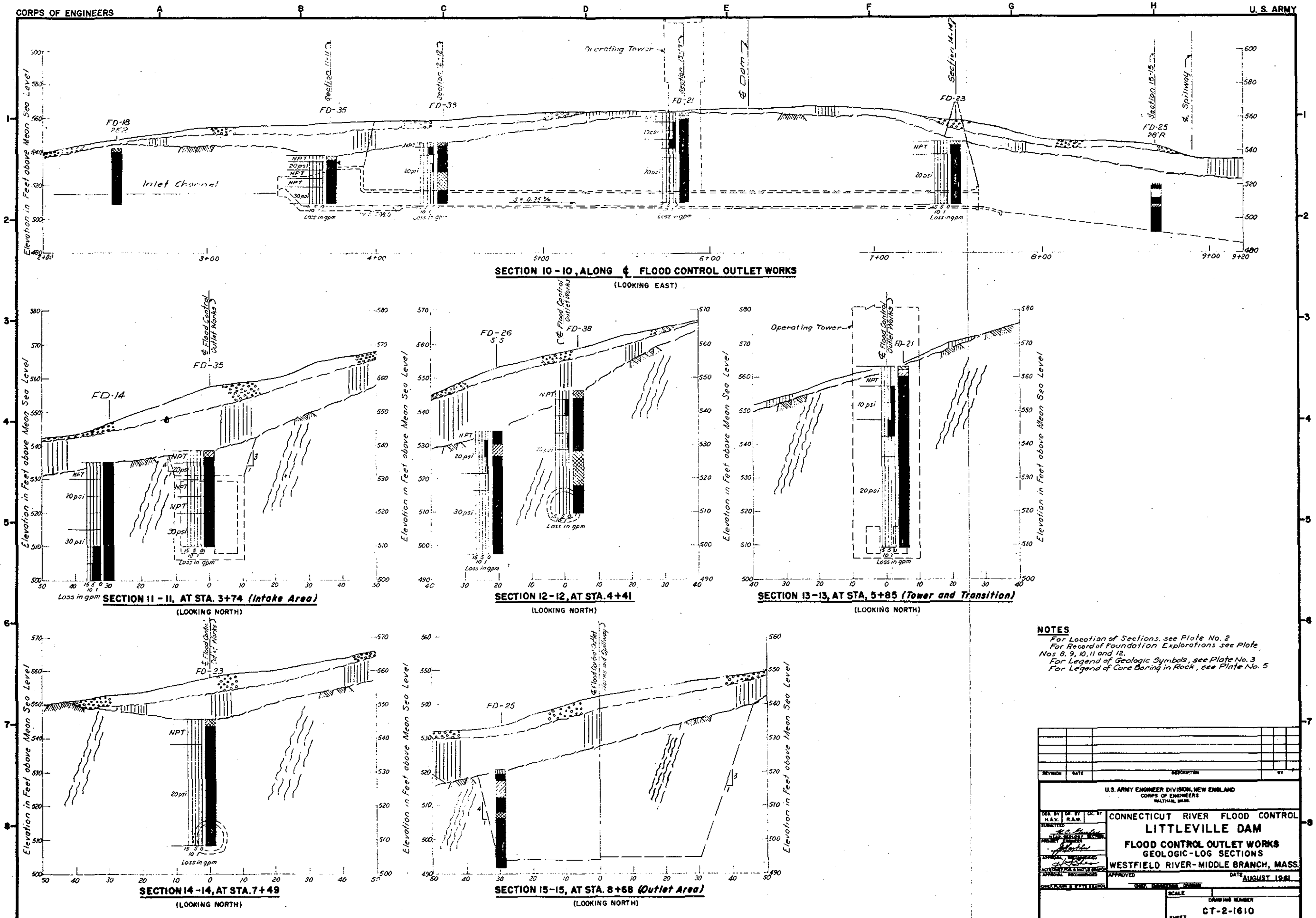
REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

CONNECTICUT RIVER FLOOD CONTROL
LITTLEVILLE DAM
WATER SUPPLY OUTLET WORKS
GEOLOGIC-LOG SECTIONS
WESTFIELD RIVER-MIDDLE BRANCH, MASS.

APPROVED
DATE AUGUST 1961
SCALE
DRAWING NUMBER CT-2-1609
SHEET

PLATE NO. IV-5



NOTES

For Location of Sections, see Plate No. 2
For Record of Foundation Explorations see Plate Nos 8, 9, 10, 11 and 12.
For Legend of Geologic Symbols, see Plate No. 3
For Legend of Core Boring in Rock, see Plate No. 5

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY H.A.V. | DR. BY R.A.W. | CK. BY

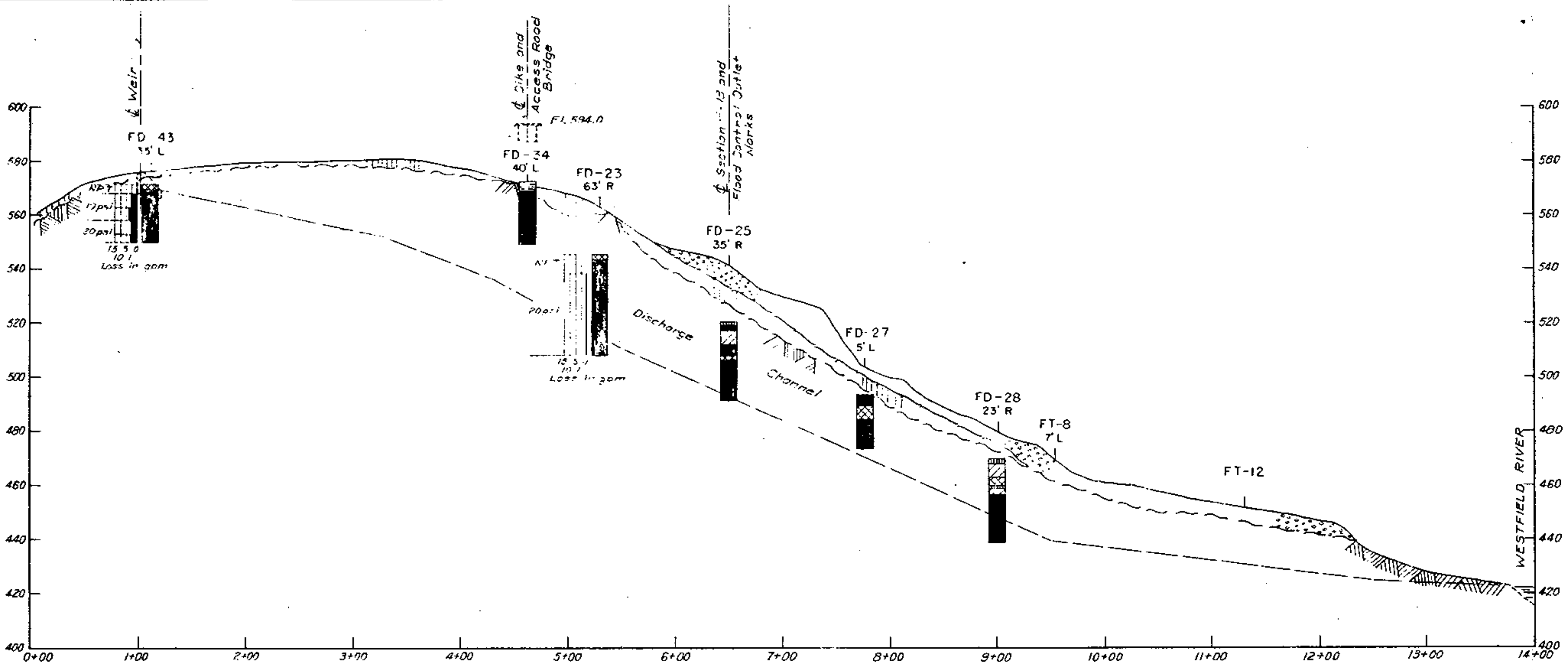
CONNECTICUT RIVER FLOOD CONTROL
LITTLEVILLE DAM
FLOOD CONTROL OUTLET WORKS
GEOLOGIC-LOG SECTIONS
WESTFIELD RIVER-MIDDLE BRANCH, MASS.

DATE AUGUST 1961

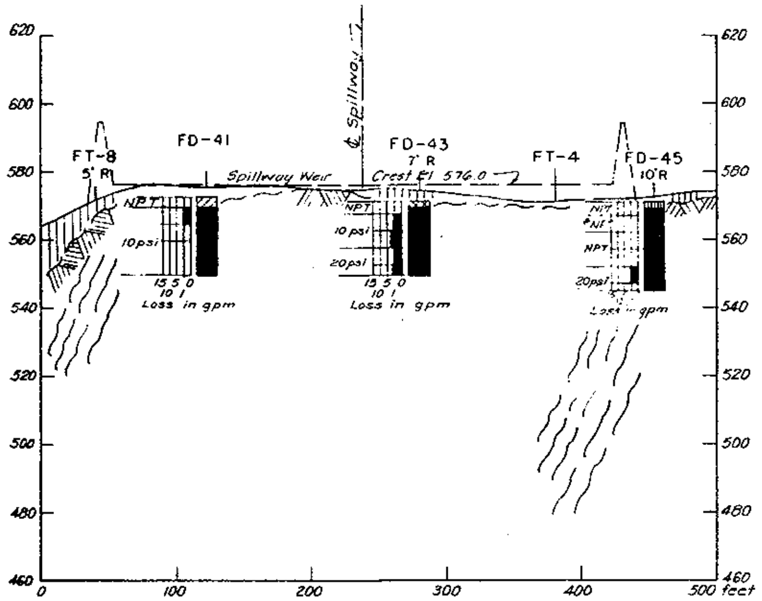
DRAWING NUMBER
CT-2-1610

PLATE NO. IV - 6

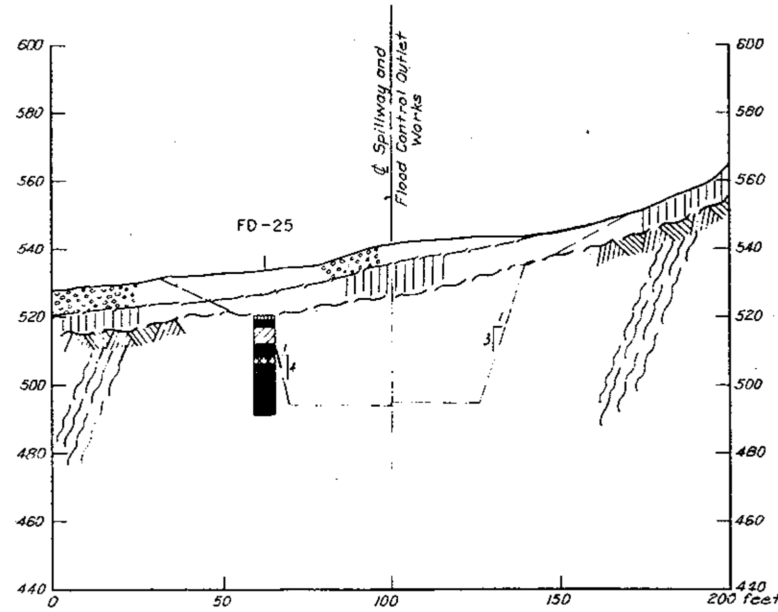
CORPS OF ENGINEERS U. S. ARMY



SECTION 16 – 16 ALONG ℄ SPILLWAY
(LOOKING EAST)



SECTION 17 – 17 ALONG ℄ WEIR
(LOOKING NORTH)



SECTION 18 – 18 AT STA. 6+50
(LOOKING NORTH)

NOTES
For Location of Sections, see Plate No. 2
For Record of Foundation Explorations see Plate Nos. 8, 9, 10, 11 and 12
For Legend of Geologic Symbols, see Plate No. 3
For Legend of Core Boring in Rock, see Plate No. 5

REVISION	DATE	DESCRIPTION	BY

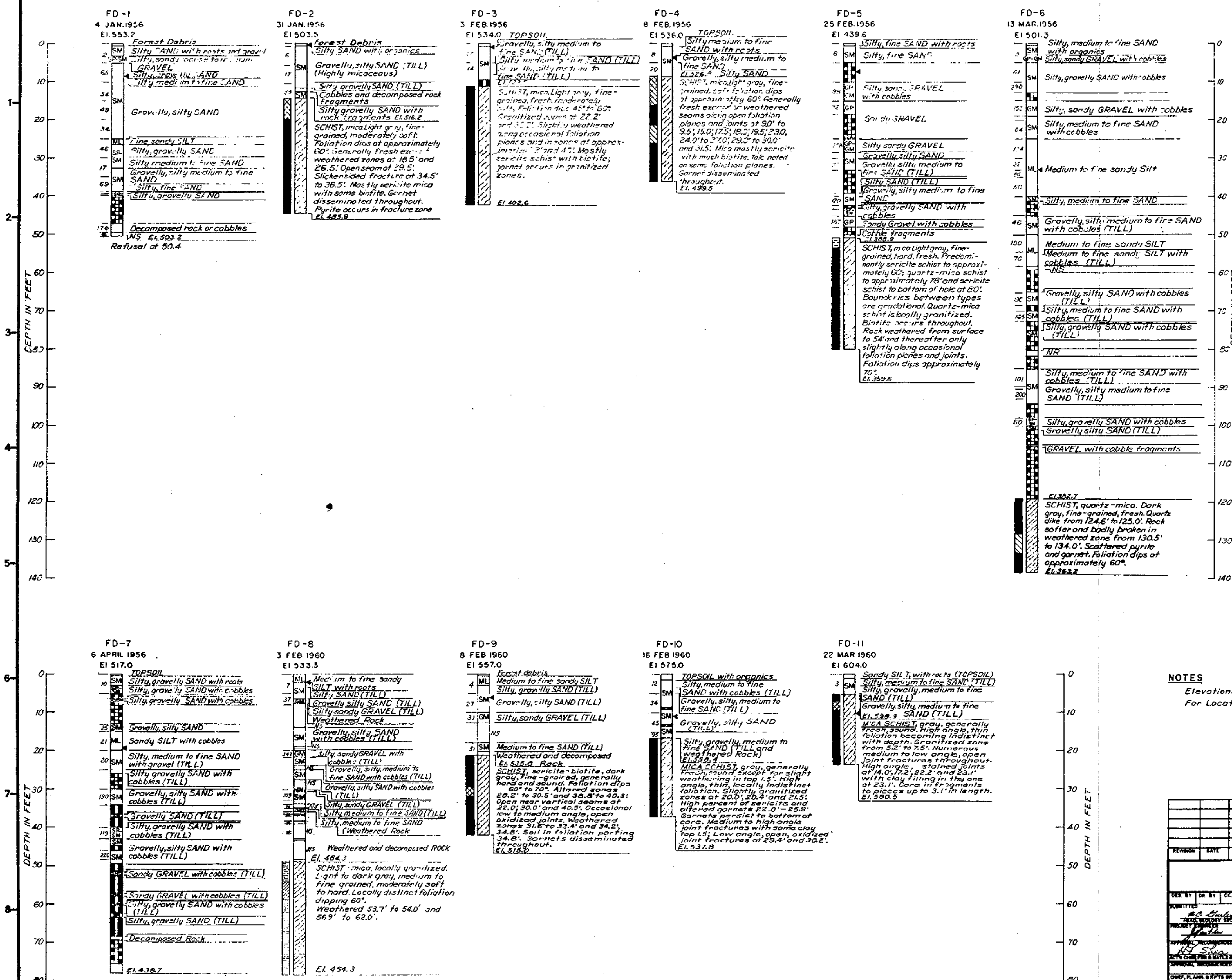
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

CONNECTICUT RIVER FLOOD CONTROL
LITTLEVILLE DAM
SPILLWAY
GEOLOGIC-LOG SECTIONS
WESTFIELD RIVER-MIDDLE BRANCH, MASS.

DES. BY | DR. BY | CK. BY
SUBMITTED
HEAD, GEOLOGY SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED
APPROVAL RECOMMENDED
APPROVED
DATE AUGUST 1961
SCALE
DRAWING NUMBER
SHEET CT-2-1611

PLATE NO. IV – 7

CORPS OF ENGINEERS | U. S. ARMY



LEGEND FOR GRAPHIC LOGS

FD — Foundation Test Boring
FT — Foundation Test Pit
(OW) — Observation well installed
3 FEB.1956 — Date exploration completed
El 534.0 — Elevation of ground surface during time of exploration

Maximum artesian head
Subsurface water level in boring at time of exploration
Range of subsurface water during period of observation
Artesian flow encountered
SP — Group letter symbol according to Unified Soil Classification System
NR — No Recovery or unsatisfactory soils samples recovered
NS — Not Sampled. Hole advanced by Core-drilling, blasting and/or wash boring due to operational difficulty
U — Bottom of observation well
CD — Sampling in overburden by Core-drilled method
Blows per foot of penetration considered most representative for each sample drive using a 350 pound hammer with a free fall of about 18" on a 1½" I.D. or 2" O.D.; 2" I.D. or 2½" O.D. and/or 2½" I.D. or 3" O.D. size sample spoon equipped with a beveled and sharpened drive shoe.
* — Blow counts not recorded or not considered representative
Cobble or boulder (Core-drilled)
Cobbles or boulders, continuous or nested (Core-drilled and/or blasted and chopped)
El. 920.7 — Elevation of Bedrock surface
Rock symbol

Rock core recovery 0-25%
Rock core recovery 25-50%
Rock core recovery 50-75%
Rock core recovery 75-90%
Rock core recovery 90-100%

NPT — No pressure test performed. Asterisk denotes that section could not be sealed for testing
40 psi — Constantly maintained pressure for 1 to 5 minutes. Volume loss in gallons per minute under constant pressure, tested continuously in 5-foot sections
Scale expanded from 0 gpm to 1 gpm for clarification of low pressure losses.

NOTES

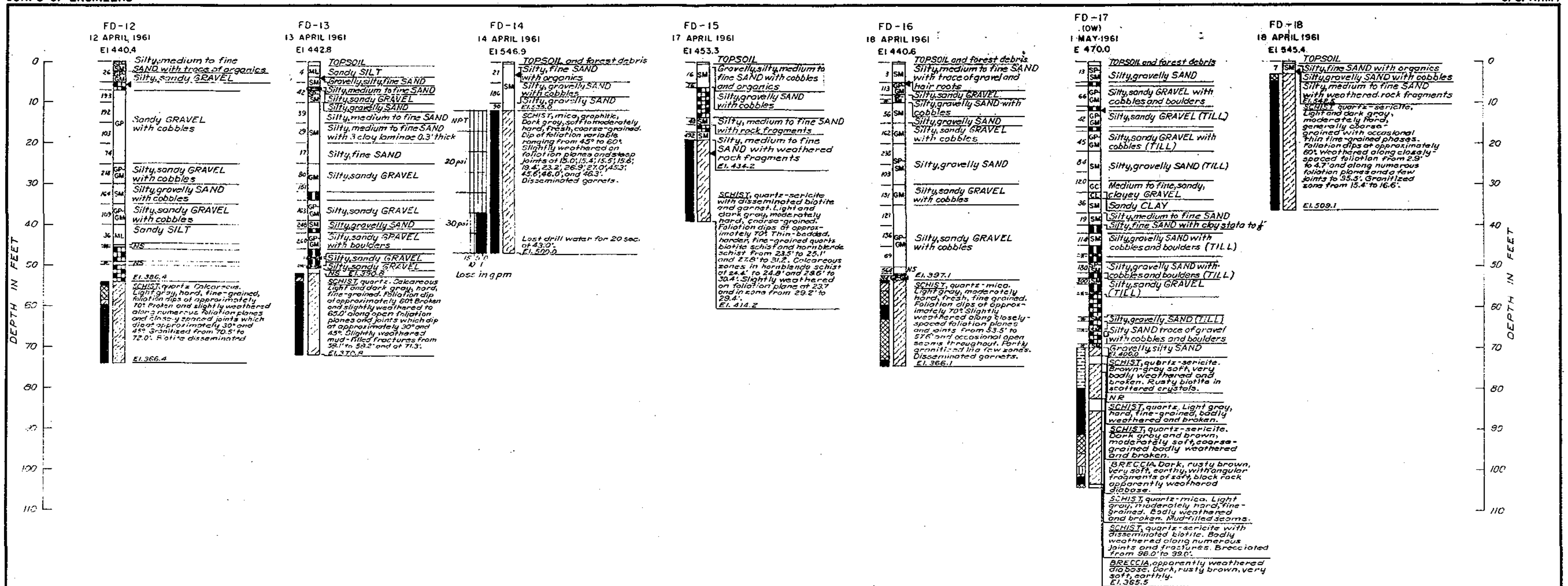
Elevations refer to Mean Sea Level Datum.
For Location of Foundation Explorations, see Plate No. 2

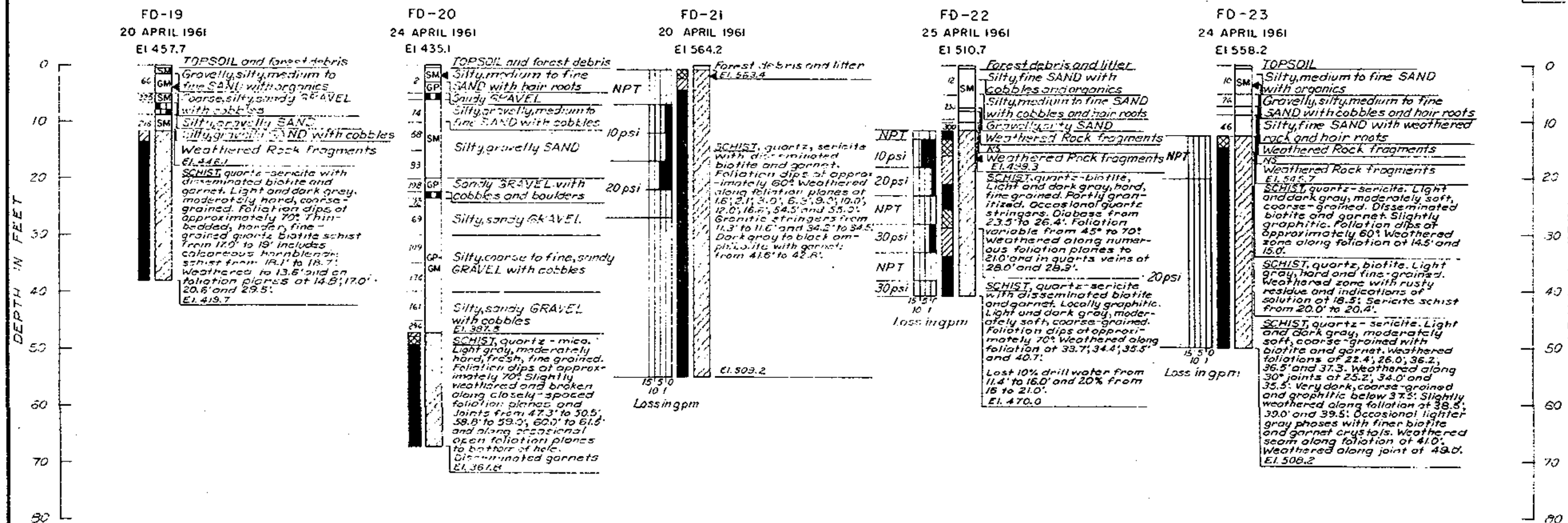
REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

CONNECTICUT RIVER FLOOD CONTROL
LITTLEVILLE DAM
RECORD OF FOUNDATION EXPLORATIONS
NO. 1
WESTFIELD RIVER-MIDDLE BRANCH, MASS.

SUBMITTED: HEAD, GEOLOGY SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED: ACTG CHIEF, FDN & MATLS BRANCH
APPROVAL RECOMMENDED: CHIEF, PLANN. & RPTS BRANCH
APPROVED: CHIEF, ENGINEERING DIVISION
DATE AUGUST 1961
SCALE
DRAWING NUMBER CT-2-1612
SHEET





NOTES

Elevations refer to Mean Sea Level Datum.
For Location of Foundation Explorations, see Plate No. 2
For Legend of Graphic Logs, see Plate No. 8

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

CONNECTICUT RIVER FLOOD CONTROL

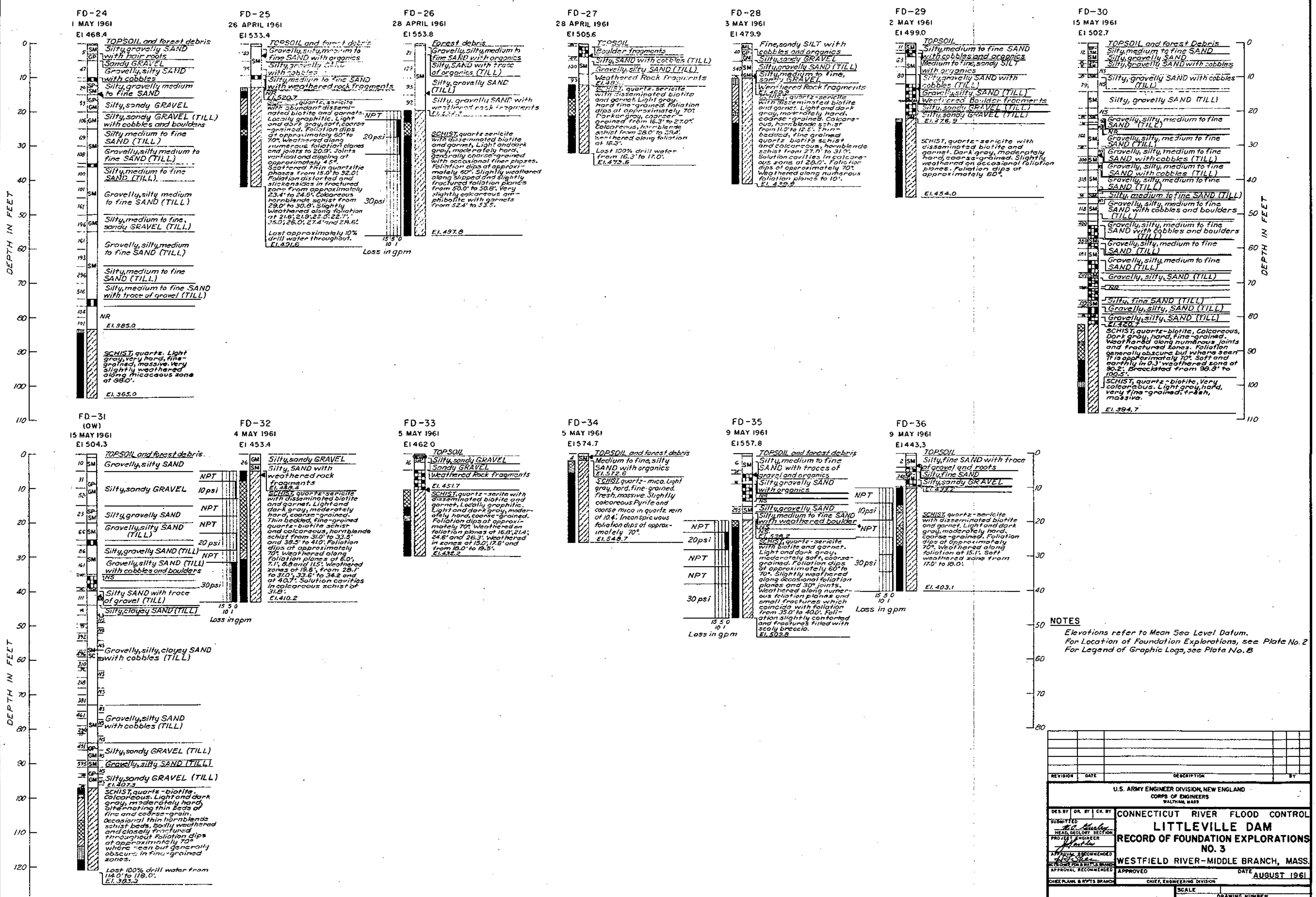
LITTLEVILLE DAM

RECORD OF FOUNDATION EXPLORATIONS NO. 2

WESTFIELD RIVER - MIDDLE BRANCH, MASS.

DES BY | DR. BY | CK. BY
SUBMITTED
HEAD, GEOLOGY SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED
APPROVAL RECOMMENDED
APPROVED
CHIEF, ENGINEERING DIVISION
DATE AUGUST 1961
SCALE
DRAWING NUMBER
CT-2-1613

CORPS OF ENGINEERS U. S. ARMY



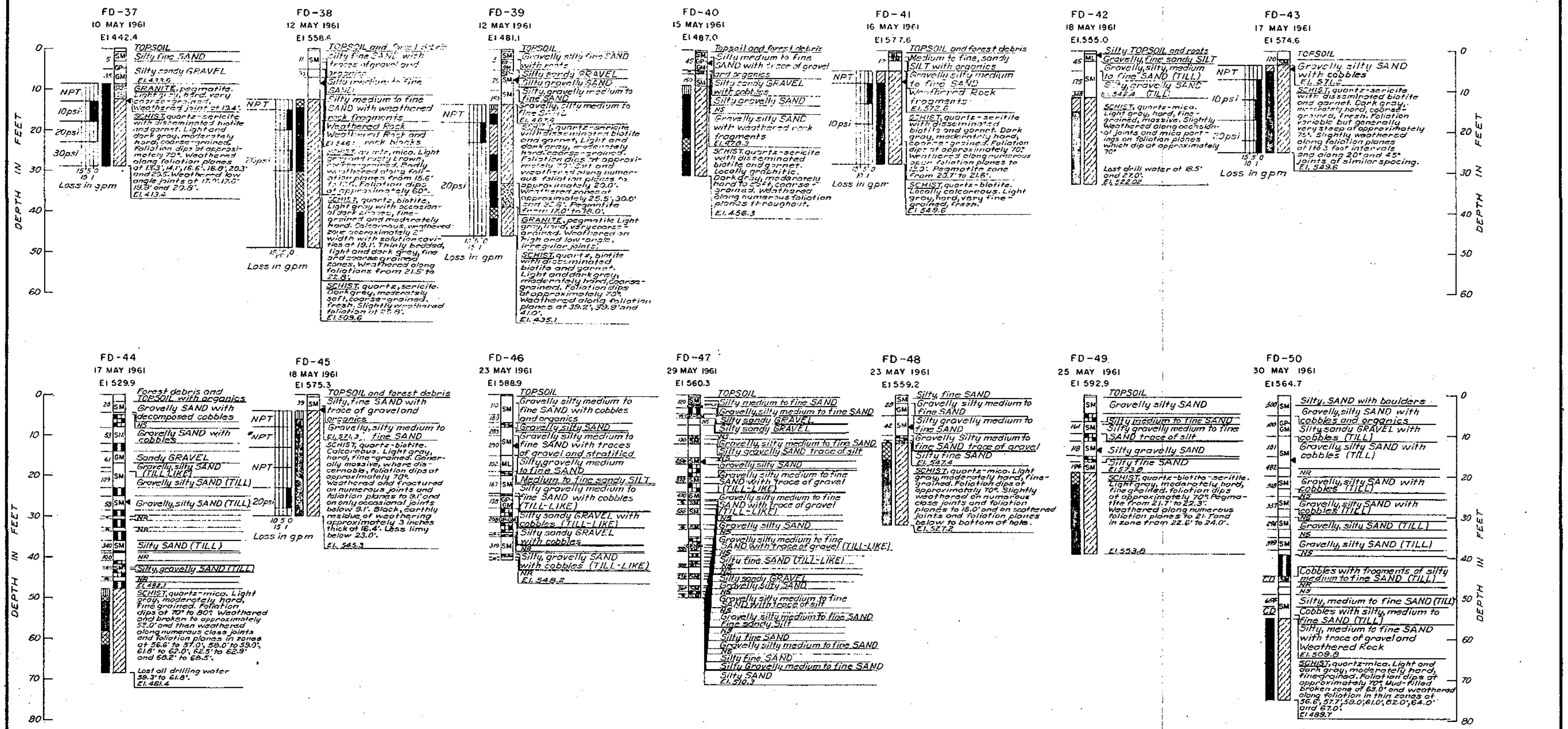
NOTES
Elevations refer to Mean Sea Level Datum.
For Location of Foundation Explorations, see Plate No. 2
For Legend of Graphic Logs, see Plate No. 8

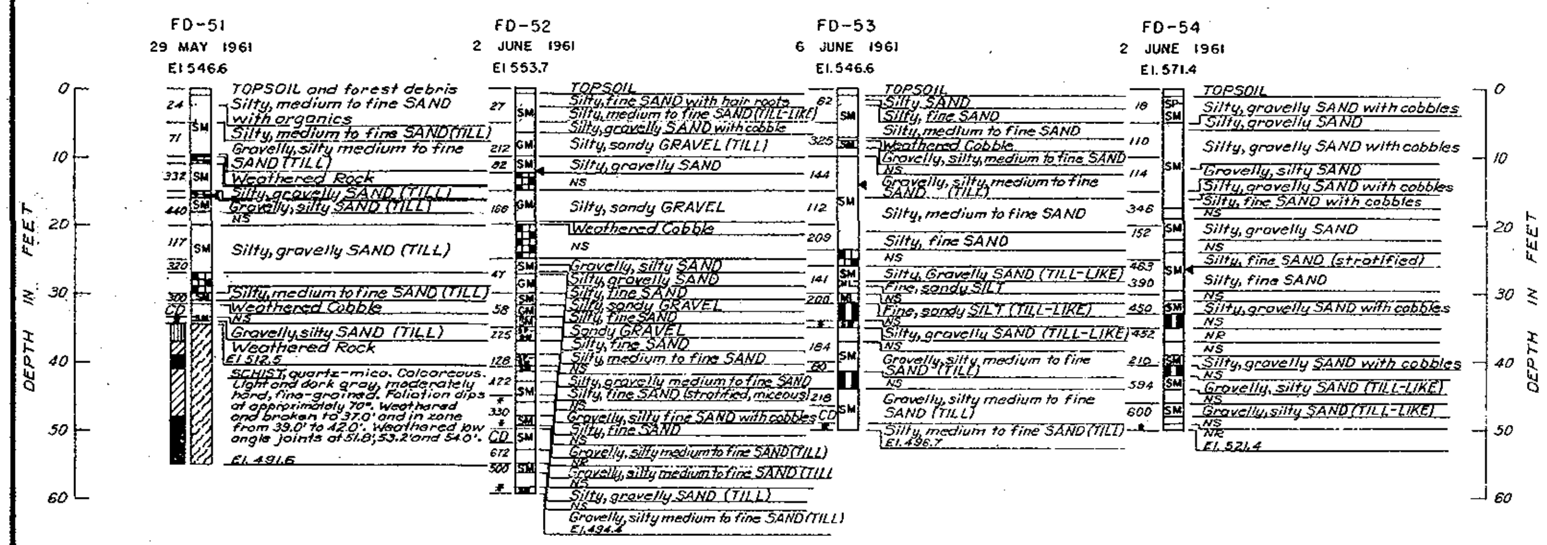
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

CONNECTICUT RIVER FLOOD CONTROL
LITTLEVILLE DAM
RECORD OF FOUNDATION EXPLORATIONS
NO. 3
WESTFIELD RIVER-MIDDLE BRANCH, MASS.

DATE AUGUST 1961
DRAWING NUMBER CT-2-1614

PLATE NO. IV-10





NOTES

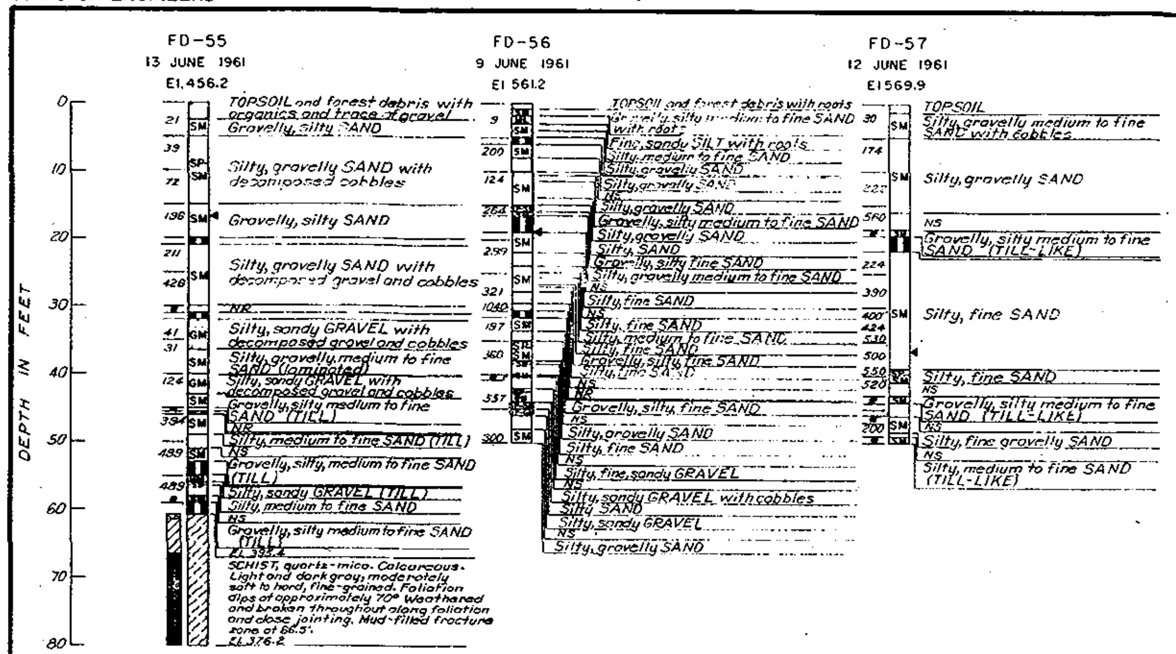
Elevations refer to Mean Sea Level Datum.
For Location of Foundation Explorations, see Plate No. 2
For Legend of Graphic Logs, see Plate No. 8

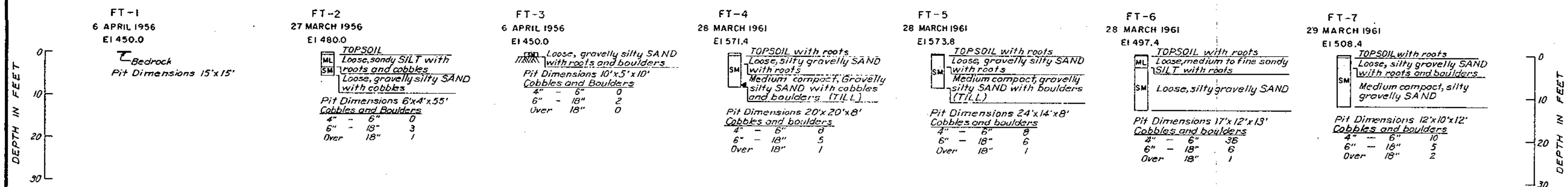
REVISION	DATE	DESCRIPTION	BY

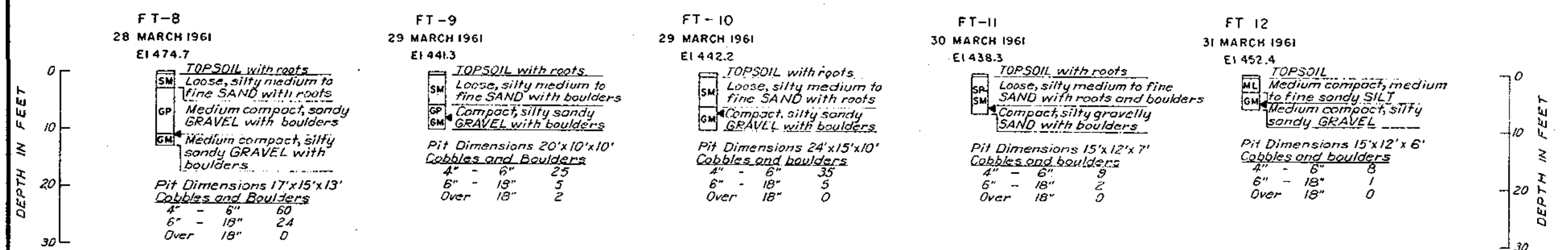
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

CONNECTICUT RIVER FLOOD CONTROL
LITTLEVILLE DAM
RECORD OF FOUNDATION EXPLORATIONS NO. 4
WESTFIELD RIVER-MIDDLE BRANCH, MASS.

DATE AUGUST 1961
DRAWING NUMBER CT-2-1615







NOTES

Elevations refer to Mean Sea Level Datum
For Location of Foundation Explorations, see Plate No. 2
For Legend of Graphic Logs, see Plate No. 8

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS

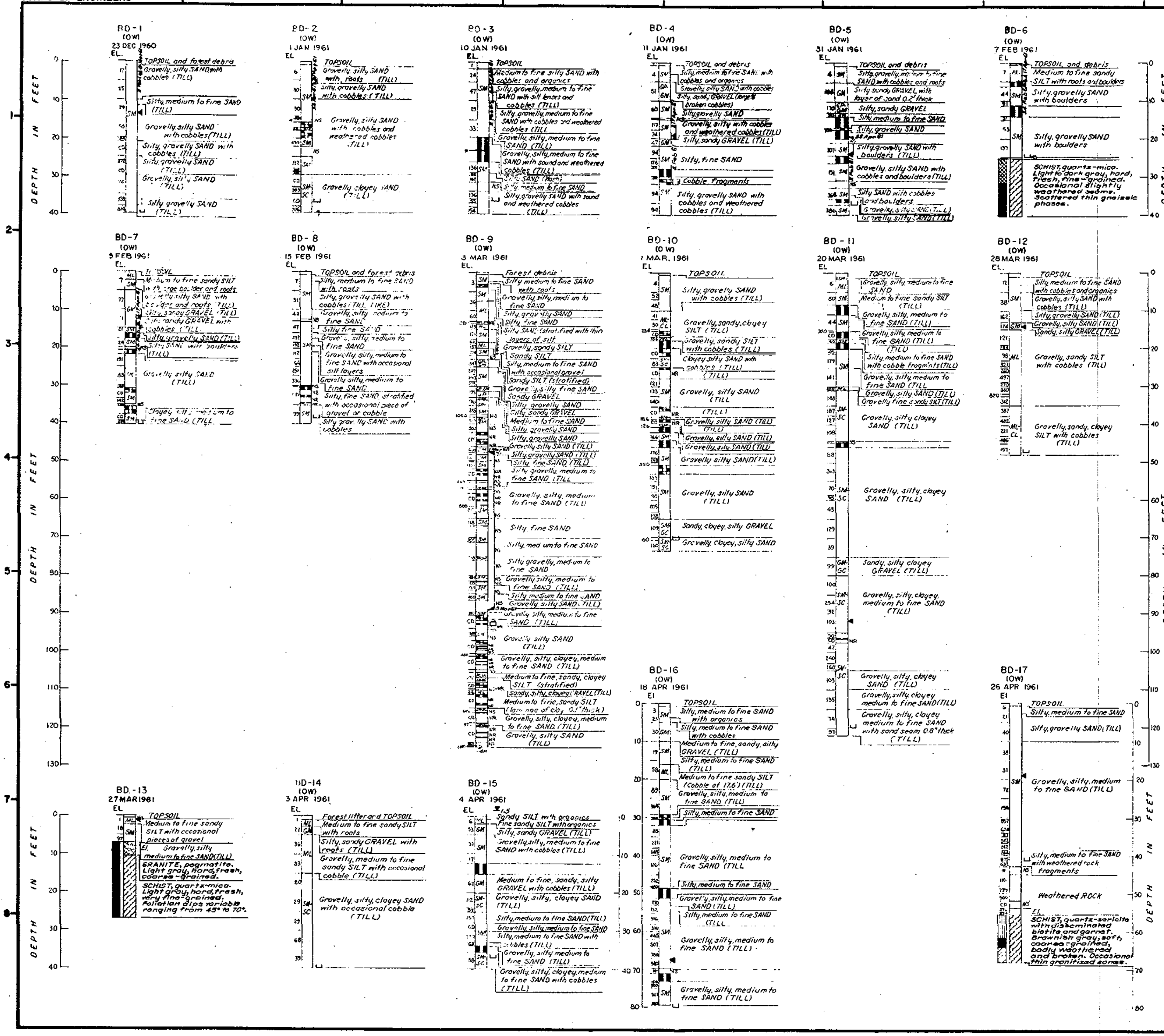
DES. BY | DR. BY | CK. BY

SUBMITTED: H.C. Charley — HEAD, GEOLOGY SECTION
PROJECT ENGINEER
APPROVAL RECOMMENDED — ACTG CHIEF, FDNS & MAT'LS BRANCH
APPROVAL RECOMMENDED — CHIEF, PLANN. & R'PTS BRANCH

CONNECTICUT RIVER FLOOD CONTROL
LITTLEVILLE DAM
RECORD OF FOUNDATION EXPLORATIONS NO. 5
WESTFIELD RIVER-MIDDLE BRANCH, MASS.

APPROVED — CHIEF, ENGINEERING DIVISION
DATE AUGUST 1961
SCALE
DRAWING NUMBER CT-2-1616

CORPS OF ENGINEERS — U. S. ARMY



NOTES

Elevations refer to Mean Sea Level Datum.

For Legend of Graphic Logs, see Plate No. 8

Borings BD-1 thru BD-7 inclusive, located in Area A Impervious. Borings BD-8 thru BD-17 inclusive, located in Area B Impervious.

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

CONNECTICUT RIVER FLOOD CONTROL

LITTLEVILLE DAM

RECORD OF BORROW EXPLORATIONS AREAS A AND B (IMPERVIOUS)

WESTFIELD RIVER-MIDDLE BRANCH, MASS.

DATE AUGUST 1961

DRAWING NUMBER CT-2-1617

PLATE NO. IV - 13